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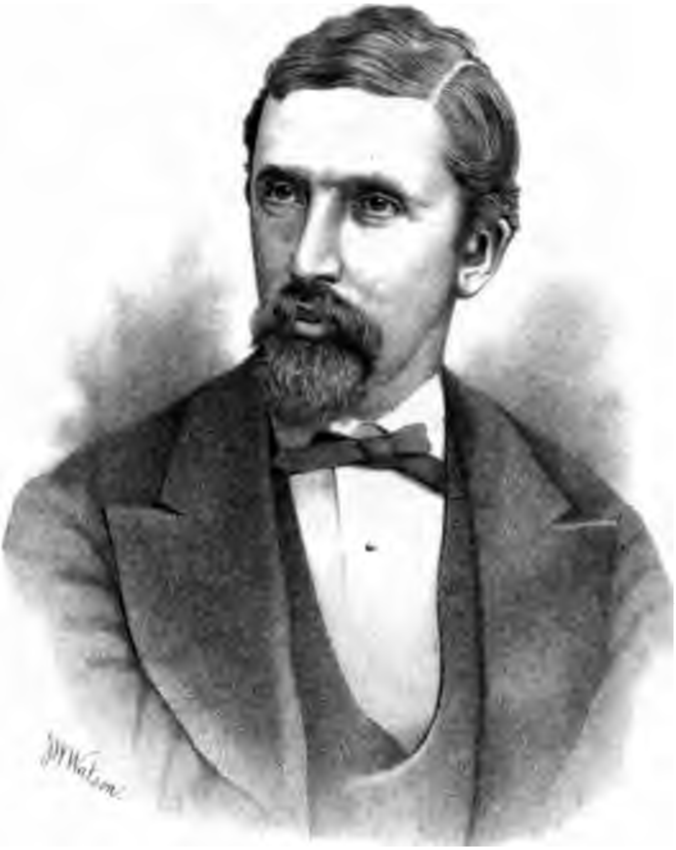

Yours very truly
G. Linnarsson.

Dr J. G. Linnarsson.
*Palaeontologist to the Geological Survey of Sweden.*
*Obit: Sept. 19th 1881.*

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## ORIGINAL ARTICLES.

### I.—The Life and Work of Linnarsson.

(With a Portrait.)

By Charles Lapworth, F.G.S.;
Professor of Geology, Mason Science College, Birmingham.

ON the 19th of last September there passed away from among us one of the most original and successful of the geologists of the century—Dr. Gustaf Linnarsson, the eminent palæontologist of the Geological Survey of Sweden. His death was so sudden and so unexpected that his sorrowing friends have as yet hardly recovered from their grief and astonishment at the blow, and are not fully awakened to the magnitude of their loss.

The geologists and palæontologists of Sweden have long stood pre-eminent in Europe for their enthusiasm, their perseverance, and their extraordinary success. The land of Linnæus has been fruitful of first-rate scientists. The works of Dalmann, Wahlenberg, Hisinger, and Angelin have made the Lower Palæozoic rocks and fossils of Sweden classic to the geological student. The present Swedish school, which includes within its bounds such men as Nordenskiöld, Lindström, Lundgren, Torell, and Nathorst, stands second to none in brilliance of scientific talent, in boldness and originality of method, and in the magnitude of the results it has achieved. The wide ocean of dreamy speculation, in whose nebulous ever-receding shores the more imaginative scientists of the South believe that they discern the outlines of undiscovered all-embracing philosophies, has no attraction for these Northerners. They have little respect for the poetry of the science. They are coasters along the shores of Geology, never out of sight of land. But every fresh point sighted is made the stepping-stone to a fresh conquest. No Columbus appears among them to point the way to a new world; but on the solid ground of patient accumulation of data, and rigid inference therefrom, they are irrepressible and irresistible. The distinct individuality of mind and sturdy independence of thought exhibited by these northern scientists is in marked contrast with the half-hearted gregarious habit of opinion so frequent amongst us. Each investigator carves out his own path, uses his own eyes, tests his own results, and publishes his own conclusions, openly and fearlessly; confident in the assurance that no scientific party exists in the country sufficiently prejudiced to take offence, or sufficiently powerful to crush him. But although every single individual among them seems to be working for himself alone, yet in actual effect and reality, they are all moving forward in the same direction. They form together an army of pioneers, which is opening out new paths for the advance of scientific discovery, with a rapidity of concentrated effect that is delightful to contemplate.

Among these pioneers we now and again see one whose ardent enthusiasm, restless activity, clearness of intellect, and dominant force of mind make him a giant among his fellows. Such a one was Linnarsson. In breadth of scientific attainments, in ability for continued and intense labour, and in the magnitude of the results he achieved, Linnarsson stood head and shoulders above all his contemporaries. To one who had accomplished so much, it seemed to the lookers-on that everything was possible. It was felt that all obstacles vanished at his touch. The difficult became easy, the obscure became clear, and the complex became simplicity itself. And all this was performed with such rapidity, and with such quiet ease, that few knew at what a dreadful cost of wear and tear of body and mind it was accomplished. When at last the worn-out frame gave way, and the glowing flame of intellect went out suddenly in darkness and death, the consternation and sorrow were hearty and universal.

Jonas Gustaf Oskar Linnarsson was born on the 24th November, 1841. He was the son of the late "contract-provost" of the town of Faldköping, in Westrogothia, and his wife A. C. Salander, who still survives. Like the majority of geniuses doomed to an early death, Linnarsson, even in his extreme youth, displayed abilities far beyond his fellows. Entering the seminary of Skara in the year 1850, he gained the highest certificate of competency granted by his teachers, before he was fifteen years of age. In 1857 he became a student in the ancient University of Upsala. In 1866 he passed the usual "Candidate-Examination," and in May of the same year handed in a thesis on the "Silurian Formations in Central Westrogothia," and received his degree as Doctor of Philosophy. Having been awarded the Sederholmsk scholarship, he spent the summer of that year in geological researches in Westrogothia. These investigations he continued in the following year, his expenses being defrayed by a special grant from the Swedish Academy of Sciences. In 1868 he attended the Congress of Naturalists at Christiania, and subsequently made a careful study of the classic geological sections of the Lower Palæozoic rocks in the neighbourhood of that city. In 1869 he was commissioned by the Academy of Sciences to make a special scientific investigation of the *Eophyton* sandstone of Westrogothia.[1] During the same year he lectured upon geology and mineralogy in the University of Upsala, in the absence of the ordinary professor of these subjects. At that date, also, he was offered the post of Palæontologist to the Swedish Geological Survey. This he accepted, fulfilling the duties with brilliant success until his untimely death. Aided by a special grant of national money, he made a scientific tour in 1869 through the prolific Lower Palæozoic regions of Bohemia and the Baltic Provinces. In 1872 and 1873 he acted as Professor of Geology and Mineralogy in his mother University of Upsala. In 1873 also he visited the Congress of Naturalists at Copenhagen. In 1875 he was promoted to the dignity of Geologist upon the Government Survey, and in this capacity he devoted all his energies for the last six years to the investigation of the stratigraphy of the Lower Palæozoic Succession in Scania, Småland, Westrogothia, Ostrogothia, Delarne, Jemtland, as well as that of the islands of Gothland and Öland, and of various portions of Norway. He was a member of the Geological Society of Stockholm, and filled the office of Assistant-Secretary during the years 1872 and 1876. He was made Secretary in 1877, and held the post until the 3rd of February, 1881, when he voluntarily relinquished it. He died at Sköfde, Westrogothia, on the 19th of September, 1881.

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[1] [illegible] Geol. Mag. 1869, Vol. VI. pp. 393-406, Pl. XI. XII. and XIII.

Linnarsson's bodily constitution appears to have been but a weak one at the best; and for several years before his death he was a victim to the wasting disease of the lungs which finally caused his death. His sufferings were borne throughout with manly resignation and uncomplaining fortitude. Year by year, as the short Swedish summer came round, and the sunny season promised delightful days to the geologist in the field, a fresh attack of the old complaint tore him away from the work he loved, to stagnate in painful inaction in various sanatoria. But even there his cheerful hopefulness never seems to have deserted him. Some of the most kindly and delightful letters I ever received from him are dated from the Sanatorium of Gausdal in the Norwegian Highlands. In truth, his intense scientific ardour gave his body but little real rest. His mind and pen were never idle, and at the least sign of renewed health he hurried to the field to his duties again. Absorbed in the keen delights of his original research, rewarded, as it always was, with almost instant and brilliant discovery, Linnarsson seems never to have adequately realized the deadly nature of his disease. His enthusiastic mind overbore and overtasked the weakly frame, and in the keen ardour of the scientific chase, the proper precautions for the bodily rest and refreshment seem to have been often overlooked and forgotten. When we recollect the disheartening and prostrating effects of these repeated attacks of illness, at the only period of the year when field-work was possible, the remarkable scientific successes he achieved during the last ten years, and the vast amount of intellectual labour he must have accomplished, appear little short of miraculous. In August of the present year he was compelled to pay his usual visit to the sanatorium at Gausdal. Feeling, as he imagined, greatly improved in health, he ventured to return, on the 1st of September, to the scene of his geological labours in Ostrogothia. Here, the weakly invalid, intent upon his loved pursuit, forgot, as usual, the deadly risks he ran. After exhausting himself in field-work during the day, he was forced to rough it at night in a miserable country inn, during the height of the rainy season. The result was inevitable. The old complaint returned with tenfold intensity, and he was driven to the shelter of his brother's home at Sköfde. It is doubtful if he had any presentiment of the fatal nature of this last attack; for a week before his death he writes to his old friends and companions on the Survey in Stockholm as bright and hopefully as ever. Then all is silence; and the news of his death burst like a thunderclap upon the ears of the many who knew him and loved him.

In the death of Linnarsson both Geology and Palæontology suffer a gigantic, and indeed an almost irreparable loss. In his familiarity with the order of succession, and the characteristic fossils of the Lower Palæozoic formations of Sweden, he stood far above all his contemporaries. We shall best understand the order and magnitude of his labours, if we regard him as what he really was, namely, the natural successor of Angelin. Like Angelin, his first palæontological work was performed among the Trilobita; and, like Angelin also, he founded the proposed stratigraphical divisions of the strata he studied, essentially upon palæontological considerations. But Angelin's *Geological* work sinks almost into insignificance when placed side by side with that of Linnarsson. Angelin was a devoted student of palæontology, and the collections of fossils at his disposal were so rich that their study absorbed the whole of his time, and he had but little leisure to devote to the examination of the various horizons of his fossils. Hence, vast as was his knowledge of the fossil forms of Sweden, he distinctly failed in developing a reliable general classification of the strata containing them. "It was reserved for Linnarsson to unravel the entire Lower Palæozoic succession of Southern Sweden" from the basal beds of the Cambrian to the unplaced sandstones at the summit of the Silurian, "and to magnificently extend, develope and correct what had already been worked out by Angelin himself." Angelin's classification of the transition strata was a mere outline, founded upon the local characteristics of the successive formations as shown by their Trilobitic faunas; and consisted of the following Regions in supposed descending order:—

8. E. Regio Cryptonomyorum.
7. D.E. ,, Harparum.
6. D. ,, Trinucleorum.
5. C. ,, Asaphorum.
4. B.C. Regio Ceratopygarum.
3. B. ,, Conocorypharum.
2. A. ,, Olenorum.
1. ,, Fucoidarum.

Region 1 included the basal non-fossiliferous strata of Sweden; regions 2 and 3 embraced the equivalents of the Primordial zone of Barrande; regions 4, 5, and 6 belonged to Murchison's Lower Silurian system; and regions 7 and 8 represented his Upper Silurian.

At Angelin's death, geologists had but a vague idea even of the broader features and probable limits of these palæontological regions; nor was their author himself by any means certain of the position of some of them in the order of succession. At the present day, however, it may be asserted with truth, that the Lower Palæozoic succession in Sweden is better known to geologists in Europe than that of Wales itself. The grander formations which compose it have all been recognized and named; while a host of subordinate zones and horizons have been discovered. By all earnest students of Palæozoic geology the Swedish sequence is regarded as the most reliable and authoritative standard of reference yet defined. And this magnificent result we owe almost wholly to Linnarsson's personal labours, and to the influence of his example upon his fellow-workers.

Linnarsson was one of those rare geologists who have learnt that in developing the true succession in any region, stratigraphy and palæontology must work together hand in hand. We see the guiding thread of this conviction running through all his researches, and it is to this, I believe, we owe it that he accomplished so much, and performed it so perfectly. The difficulties he had to encounter were altogether distinct from those which beset the student of the fossiliferous Lower Palæozoic rocks of Britain. In Southern Sweden the strata are of such remarkable tenuity that the fossils peculiar to several subformations in the vertical series lie in close proximity; and unless collected inch by inch, *in situ*, are certain to become intermixed in the collection. The floor of the country is so buried up from sight by the universal mantle of drift, that exposures of strata are few and far between; and it is impossible to trace any of the beds from point to point over the ground. In such a region no one could hope for success but he who possessed an eye trained to recognize the most minute distinctions in petrological and palæontological characters in the field, a memory gifted to retain them, a power of generalization sufficient to group them at once in their natural relationships, a faith in his own judgment enough to follow the conclusions they indicated to their widest issues, and above all an intense delight in the labour itself. Linnarsson, pre-eminent among his contemporaries, seems to have possessed all these qualifications, and his success was proportionably great.

Linnarsson's geological career falls very naturally into three very distinct periods. In the first of these, 1866 to 1870, he employed himself in working out the geology of the district of Westrogothia, and in establishing on both stratigraphical and palæontological grounds a detailed scheme of its Lower Palæozoic succession. The second period, 1870 to 1876, he spent in rigidly testing and developing this scheme, and in making it available for the entire mainland of Scandinavia, by frequent and extended tours to other Lower Palæozoic areas, at home in Dalarne, Jemtland, Scania, and Öland, and abroad in Denmark, Germany, Bohemia, and the Baltic Provinces of Russia. The third period, 1876 to 1881, he occupied in field-work on the Geological Survey, in palæontological research, and in working out the subordinate zones of his original geological scheme.

The first scene of Linnarsson's geological labours was his native region of Westrogothia. The rocks and fossils of this region had been already made known to geologists in the works of Linnæus, Wahlenberg, Dalmann, Hisinger, and Angelin; but it was reserved for Linnarsson to detect the true order of succession amongst them, and to make them the accepted prototypes of all the corresponding formations of his native land. Linnarsson commenced the study of the Lower Palæozoic strata of this district immediately after his candidate-examination in 1866. His first geological paper—"On the

Silurian Formations of Westrogothia"—was published in the same year, and is the first of a series, which was destined to make this special region classic in the history of geological discovery. His second paper—entitled "Contributions to the Geology of Westrogothia,"—although a mere provisional sketch, was a most remarkable contribution to the scientific literature of the country. It placed for the first time the Lower Palæozoic succession of rocks and fossils in this region upon a reliable basis, and demonstrated the insufficiency of Angelin's classification of the Swedish Transitional strata. In this paper Linnarsson made known the presence of several formations in Westrogothia that had remained undefined by previous investigators, and proposed the following scheme of nomenclature of the rocks of the region, a scheme which in its broader outlines remains substantially unmodified to the present day.

9. Upper Graptolite Beds
8. Brachiopod Shales = Angelin's Regio Harparum.
7. Trinucleus Shales = „ Regio Trinucleorum.
6. Beyrichia Limestone
5. Orthoceras Limestone = „ Regio Asaphorum.
4. Lower Graptolite Shales
3. Ceratopyge Limestone = „ Regio Ceratopygarum.
2. Olenus Shales = „ RR. Olenorum (and Conocorypharum).
1. Fucoid Sandstone = „ Regio Fucoidarum.

Of these divisions, No. 2, or Alum Shales, answers to Angelin's Regio Olenorum and Regio Conocorypharum. Angelin had placed the latter of these divisions *above* the former, solely upon the ground that in the more typical localities it was most prolific in fossils. Linnarsson showed that Angelin had inverted the true order of succession, for in Westrogothia the Regio Conocorypharum actually lay *below* the beds belonging to the Regio Olenorum. He made known also the presence of actual fossils (other than so-called fucoids) in the basal sandstones of the district. The two new formations of Upper and Lower Graptolite schists added by him to the Swedish sequence were destined to be of prime importance in the development of the geology of other areas.

After a careful comparison of these results with the phenomena presented by the corresponding Lower Palæozoic formations of the neighbourhood of Christiania, Linnarsson next published what is unquestionably his most ambitious and successful work—his memoir on "The Cambrian and Silurian Succession in Westrogothia." In this work the evidences for the conclusions advanced in his last-mentioned paper are given in full, and are fortified by an array of confirmatory evidences from other sources. Especial care is devoted to the description of the Primordial Beds or Alum Shales, which are divided by the author into five zones, viz.:

5. Beds with *Peltura scarabeoides.*
4. „ *Olenus latus* and *O. gibbosus.*
3. „ *Agnostus lævigatus.*
2. „ *Paradoxides Forchammeri.*
1. „ *Paradoxides Tessini.*

Zones 1, 2, 3, answer to Angelin's Regio Conocorypharum, and zones 4 and 5 to his Regio Olenorum.

In this memoir we see Linnarsson perhaps at his best. The mode of presentation of the subject-matter is simplicity itself. The first division of the work is a minutely-detailed account of the general petrological and palæontological features of the nine distinct Lower Palæozoic formations recognized by the author in Westrogothia, together with a sketch of their distribution in the Scandinavian areas, interspersed with remarks upon their probable extra-Swedish equivalents. In the second part of the paper the reader has laid before him a careful and highly detailed description of the most important sections in Westrogothia. The third part is essentially palæontological, but it is especially remarkable, in a geological point of view, from the fact that it includes a most elaborate table of all the known forms of Swedish Trilobita, every species being assigned, for the first time, to its proper place in the vertical series of formations.

(*To be continued.*)

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## II.—NOTES ON THE VERTEBRATA OF THE PRE-GLACIAL FOREST BED SERIES OF THE EAST OF ENGLAND.

By E. T. NEWTON, F.G.S.

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### PART VI.—AVES, REPTILIA, AND AMPHIBIA.

### AVES.

REMAINS of birds from the "Forest Bed" were known to Mr. Green in 1842 (History of Bacton), and they are mentioned by Mr. A. Bell (Geologists' Assoc. 1871), in his list of "Forest Bed" Vertebrata, as bones of indeterminable species. These appear to be the only published instances in which Avian bones from these deposits are referred to, and hitherto no closer determination has been made. This is not very surprising, for the bird bones which have been found, although in some numbers, are either in a fragmentary condition or else they are not characteristic parts of the skeleton. Portions of vertebræ, scapulæ, coracoids, and limb-bones probably indicate the existence, at that time, of at least half a dozen different forms; but at present only two genera have been identified, and one of these is very doubtful.

A portion of a large metacarpal bone, which agrees in size, form, and markings with the corresponding part of a goose's wing, is referred to the genus *Anser.* The specimen was obtained by Mr. A. Savin from the estuarine "Forest Bed" at E. Runton, and is preserved in his collection at Cromer. There is another metacarpal bone, nearly perfect, and agreeing in size with that bone in the wing of the Herring Gull; but in its form and structure it agrees better with the duck, and as we have also a portion of a coracoid likewise resembling that of the duck, it seems best to refer them provisionally to the genus *Anas?* Both these specimens are from the Freshwater Bed at W. Runton, and are in the possession of Mr. A. Savin.

Of the indeterminable specimens, the greater number belong to Mr. A. Savin, and some are in the Museum of Practical Geology.

## REPTILIA.

No reptilian remains have hitherto been recorded from the "Forest Bed Series." Mr. Green speaks of the bones and teeth of "*Sauria*"; but the specimens upon which this determination rested were subsequently shown by Prof. Owen to be parts of the common Mole (*vide* Brit. Foss. Mams. pp. 22–24). We are now, however, in a position to cite two distinct forms from these Beds.

Among some small bones which Mr. E. T. Dowson was kind enough to send me for examination, were two vertebræ, almost perfect, in which the zygantrum and zygosphene were distinct and perfectly preserved, and consequently there was no question as to their being *Ophidian*, and a careful comparison with a skeleton of the common snake in the Royal Coll. Surgeons showed that they perfectly agreed, the one with a middle, and the other with a late dorsal vertebra. These two vertebræ are therefore referred to the common snake, *Tropidonotus natrix*, Linn. They were obtained from the Freshwater Bed at W. Runton. Two other vertebræ, belonging apparently to the same species, are to be seen in the Museum of Owen's College, Manchester, and are labelled as from the "Forest Bed" at Bacton.

Another Ophidian vertebra, somewhat broken, but with zygantrum and zygosphene preserved, was obtained by Mr. Clement Reid, from the Freshwater Bed at West Runton. This vertebra is little more than half the size of the smaller of Mr. Dowson's two specimens; it is more depressed, has a less elevated neural spine, and the cupped end of the centrum is slightly oval. In fact, it differs from the above-mentioned specimens in precisely the same manner that the vertebræ of the viper differ from those of the common snake. It agrees with one of the late dorsal or abdominal vertebræ of the viper, and is referred to that species, *Pelias Berus*, Linn.

## AMPHIBIA.

No Amphibian remains have hitherto been noticed among the "Forest Bed" vertebrata, but with the bones brought together by the indefatigable zeal of Mr. Clement Reid and Mr. Savin, there are a number which are referable to this group, and some of them are of such a character as to permit of their specific determination. These remains clearly belong to the three genera, *Rana*, *Bufo*, and *Triton*, and were all found in the Freshwater Bed at W. Runton.

Two humeri having strongly developed condylar ridges, directed backwards and reaching far up the shaft, agree closely with the humeri of the male *Rana temporaria*, and differ from those of the *R. esculenta*, which has these ridges much shorter, less developed, and directed laterally. The *Rana alpina*, in Hyrtle's series of Amphibian Skeletons, in the Royal College of Surgeons, has a development of these ridges similar to those in the *R. temporaria*; but on the whole it seems most probable that these fossils belong to the common English species, and with some little doubt they are referred to *R. temporaria ?*

Other humeri have the characters of these bones as found in *Rana* *esculenta*, and are believed to have belonged to that species, but the evidence is not such as to make one absolutely certain, and therefore a note of interrogation should be placed after the species, *Rana esculenta ?*

The iliac bones of the toad present certain peculiarities which distinguish them from those of the frog—for example, the upper edge is rounded in place of being sharply keeled; and there is in the toad's ilium, an oblique groove just in front of the tubercle found above the acetabulum, and this groove is not seen in the frog. Two or three portions of iliac bones which present these peculiarities of the toad are in consequence referred to this genus, and *Bufo* must therefore be added to our list. In all probability these bones belong to the common toad, but there is not sufficient evidence to justify the insertion of the species.

A single femur, but this, fortunately, quite perfect, enables us to add *Triton cristatus* to the "Forest Bed" list. A comparison of the femurs of our two common species of urodele Amphibia, *Triton cristatus* and *Lissotriton punctata*, shows that they are dissimilar in form. This difference is well marked, and may be summed up by saying that in the *T. cristatus* the shaft is more slender and enlarges more suddenly at the distal extremity, than in the *Lissotriton punctata*. The fossil agrees with the former, and is therefore referred to the *Triton cristatus*, Laur.

LIST OF AVES, REPTILIA, AND AMPHIBIA OF THE "FOREST BED SERIES."

(Those marked with an asterisk * are new to the "Forest Bed Series.")

**Anser* sp.
**Anas ?*
Bird bones undetermined.
**Tropidonotus natrix, Linn.*
**Pelias Berus*, Linn.
**Rana temporaria ?* Linn.
*—— *esculenta ?* Linn.
**Bufo*, sp.
**Triton cristatus*, Laur.

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## III.—TRACES OF A GREAT POST-GLACIAL FLOOD.

### I. THE EVIDENCE OF THE LOESS.

By H. H. HOWORTH, F.S.A.

IN some papers which I have been allowed to print in the GEOLOGICAL MAGAZINE I have drawn the general conclusion that the Mammoth and his companions were finally overwhelmed by a great diluvial catastrophe. This conclusion I have based chiefly on other than stratigraphical evidence. If it be a reasonable conclusion, it ought to admit of being supported by such evidence, and we are, in fact, bound to meet the purely geological side of the case. Believing that this may be done with the greatest confidence, and with the most complete advantage to the theory, I now propose to examine this evidence, with all deference, and I hope also with all frankness. There is virtually no dispute about the facts. These are familiar, and admitted, and the main contention is about the inferences to be drawn from them. The following paper will, therefore, be in the main critical, and an attempt will be made in it to show that the current theories (which are very contradictory) about the Loess are inconsistent with the facts, and to formulate another theory which it is hoped may prove to be more consonant with them. The only demand I make *in limine* is that the position shall be examined impartially and untrammelled by *à priori* theories, which are more agreeable to theological than to scientific modes of reasoning. Theories which, however supported by great names, are mere tentative hypotheses, excellent as working hypotheses so long as they explain the facts, but to be discarded directly our induction shows them to fail in so explaining them.

It will be convenient to begin our examination with the Loess or Lehm of German writers. Sir Charles Lyell, in speaking of the Loess, says, "Some skilful geologists, peculiarly well acquainted with the physical geography of Europe, have styled the Loess the most difficult geological problem, although belonging to the period of existing land-shells and the highest and newest by position of all the great formations" (Antiquity of Man, p. 372).

Much has been written upon the Loess since Sir Charles Lyell penned these weighty words; but it may be fairly said that the difficulties in regard to it seem greater and more insoluble now than at any previous epoch of geological inquiry. It has been the fashion to correlate the Loess with the loamy deposits of France and South Russia and the brick-earths of Britain, etc. This view we believe to be erroneous. Neither in structure nor in origin is the Loess to be compared with the diluvium of the French writers nor with our brick-earths. And in this paper we shall limit the term strictly to the Loess proper, or Lehm, which is otherwise called, according to Von Leonhard, in various parts of the Rhine Valley, Loesch, Schneckenhausel-Boden, Mergel and Briz (Hibbert-Ware, Volcanoes of Neuwied, p. 185).

The first important fact we have to face is that the Loess of Central Europe and of China is precisely the same in composition, distribution, and contents. The European Loess has been graphically described by Mr. Geikie, and I cannot improve on his description. He speaks of it as "a yellow or pale greyish-brown, fine-grained, and more or less homogeneous, consistent, non-plastic loam, consisting of an intimate admixture of clay and carbonate of lime. It is frequently minutely perforated by long vertical root-like tubes, which are lined with carbonate of lime, a structure which imparts to the Loess a strong tendency to cleave or divide in vertical planes. Thus it usually presents upright bluffs or cliffs upon the margins of streams and rivers which intersect it. Very often it contains concretions or nodules of irregular form, which are known in the Rhine district as Loessmännchen or Loesspüppchen and in that of Danube as Loesskindeln" (Prehistoric Europe, p. 144). With this account of the Loess of Germany may be compared that given by Richthofen of the Chinese Loess. He says, "The Loess is among the various substances which would commonly be called loam, because it is earthy and has a brownish-yellow colour. It can be rubbed between the fingers to an impalpable powder, which disappears in the pores of the skin, some grains of very fine sand only remaining. By mechanical destruction, such as is caused by cart-wheels on a road, it is converted into true loam. When in its original state, it has a certain solidity, and is very porous, and perforated throughout its mass by thin tubes which ramify like the roots of grass, and have evidently their origin in the former existence of roots. They are incrusted with a film of carbonate of lime. Water, which forms pools on loam, enters therefore into Loess as into a sponge, and percolates it without in the least converting it into a pulp or mud. . . . It is not stratified, but has a strong tendency to cleave along vertical planes; therefore, wherever a river cuts into it, the Loess abuts against it, or against its alluvial bottom land in vertical cliffs, which are in places 500 feet high: above, the slopes recede gradually in a series of terraces with perpendicular front faces" (Journ. Geol. Soc. vol. xxvii. p. 377). The exact parallel of the Chinese and European Loess is carried out in their contents; in the shells and debris of animal life which they contain. The Père David, whom I shall again have occasion to quote, tells us he found the Loess of the Yellow River characterized by the shells of *Helices* such as still live in China, while in the Loess of Mongolia he found broken bones of *Elephas primigenius*, *Rhinoceros tichorhinus*, several unknown kinds of *Cervus*, of Horses, Oxen, etc., but adds that when he wrote neither he nor Richthofen had seen traces of Palæolithic man (Journal de mon Troisième Voyage, etc., vol. i. p. 93). Pumpelly also tells us that the Chinese in digging the caves in the Loess, in which so many of them live, find the bones of *Cervus*, etc. The parallel with the European Loess is also carried out in the concretions of carbonate of lime. Of this latter in the Loess of China Mr. Kingsmill says "they have segregated from the mass in nodules of fantastic shapes, which show from the vertical position of their major axis their subsequent origin." In every respect, therefore, the Loess of China and of Europe resemble one another except in the enormous development of the formation in the former area compared with the latter, and there can only be one conclusion from a dispassionate survey that it was deposited under the same conditions in both areas.

We will now consider the limits of the Loess properly so-called. It is found largely developed in the main valleys of the Rhine and the Danube and in those of their tributaries, and in notably thick deposits in the valleys of the Neckar, the Main, and the Lahn. Lyell tells us the northern limit of the Loess "has been marked out about the 51st parallel of latitude by MM. Omalius, d'Halloy, Dumont, and others, as running east and west by Cologne, Juliers, Louvain, Oudenarde. and Courtray in Belgnim, to Cassel, near Dunkirk, in France. South of this line, according to M. d'Archaic, it envelopes Hainault, Brabant, and Lemburg, like a mantle everywhere uniform and homogeneous in character, filling up the lower depressions of the Ardennes, and passing thence into the North of France. . . . But as we go southwards and eastwards of the basin of the Seine, it diminishes in quantity, and finally thins out in those directions" (Lyell, Antiquity of Man, pp. 376, 377).

Going east, Loess abounds in the valley of the Upper Elbe, from below Meissen to Perna, and especially in Bohemia; in the valleys of the Weser, Mulde and Saale, and in the Hartz Mountains. In the valleys of the Upper Oder and the Vistula it occurs at an elevation of 400 mètres. It stretches from Upper Silesia right away into the great Polish plain, and is found of a thickness of thirty mètres at Sandomir (Credner, pp. 669 and 670). It abounds in Hungary and Moravia, in Gallicia, the Bukovina and Transylvania, going far up into the Carpathians. It also abounds in Roumania, but has not been observed south of the Balkans (Geikie, Prehistoric Europe, p. 146). It is not found in Russia, nor yet in the flat country bordering the Baltic and the North Sea, Hanover, Prussia Proper, and Northern Poland, which are strewn with Drift, but dies out in all directions as we leave the masses of mountains in Central Europe, where it has its focus. This distribution of the European Loess, as will be seen presently, is an important factor in the problem of its origin.

Let us now turn to the Chinese Loess. Richthofen found it at Chin-kiang and Nan-king, on the Yang-tsze-kiang and throughout almost the entire area of the great governments of Honan and Shansi. Mr. Kingsmill says it extends from the south of the Yang-tsze, in the Prefecture of Chin-kiang, far into Mongolia on the north, and from Anhwei on the east to an unknown distance west, in all probability far into Central Asia (Journ. Geol. Soc. vol. xxvii. pp. 376 and 381 and 382). Père David also speaks of it as specially abounding in the south of Mongolia, in the country of the Tumeds and the Urats. It is a remarkable fact that, as in Europe the central masses of mountains are the focus of distribution of the Loess, so in the furthest east the chain of mountains in Southern Mongolia is also the focus of the deposit, which thins away thence as we advance towards the south, disappearing a little beyond the Yang-tsze-kiang, and disappearing also as we travel northwards towards Siberia. This mode of distribution, as we have said, and shall show presently, is of very great importance in the solution of the difficulties that surround the Loess.

Let us now glance at the various theories which have been proposed to meet these difficulties. The earliest theory, which was first propounded by Bennigsen Förder, was that the deposit is of marine origin. This view is I fancy now limited to Mr. Kingsmill, and was entirely repudiated by every speaker when Mr. Kingsmill's paper was read at the Geological Society. The objections to it are overwhelming. In the first place a mineral deposit formed of inorganic particles so heavily charged with a material like carbonate of lime could hardly be deposited from sea-water. In the next place the Loess, although abounding in organic remains, has in no single instance yielded a trace of a marine organism; this objection alone is paramount. Thirdly, the Loess is practically homogeneous and unstratified. It is true that concretions occur in it, as they have accumulated *in sitû*, from the deposit of carbonate of lime about nuclei; but these have been formed in this way *in sitû*, and are not evidence of stratification at all. Such a thing as *an unstratified* marine deposit 1000 feet thick, quite homogeneous throughout, as is the case with the Loess of China, is unknown, and is *prima facie* impossible. Lastly, the postulating of a change of level of at least 6000 feet in China, in quite recent geological times, and of a very extensive and wide-spread change in Europe also, is invoking a quite stupendous cause to account for what is much more completely accounted for by a much simpler one. On every ground we may conclude that there is no evidence that the sea has ever overspread the two continents of Asia and Europe since the deposition of the Loess, but, on the contrary, all the evidence points to the Loess having been other than a marine deposit.

Having discarded salt-water and its partizans, we must now consider the theories of those who make the Loess a fresh-water deposit. Some of these argue that it is of lacustrine, and others of fluviatile origin. Both agree that lake and river, however, are merely instruments by which the Loess was distributed, and urge that its *origin* is to be traced to the glacial mud formed by Alpine and other glaciers at the time when the Ice Age predominated. In this view all the partizans of fresh-water are agreed. Lyell, Belt, and Geikie, differing in other respects, are at one in this. Yet we may seriously ask on what possible ground, save a purely hypothetical one, this view has been maintained. The Alpine glaciers are no doubt much smaller now than they were in the great Ice Age, but otherwise they are doing precisely the same work, grinding the same rocks, and pouring out the same debris of denudation. Their great outlets, the Rhine and the Rhone in the North, and the Po in the South, are carrying seawards the same kind of matter in suspension that they formerly did. At all events, if this be not so, the burden of proof of showing the contrary is assuredly upon those who deny the fact. If this be so, how comes it that nothing like the Loess is being manufactured now by the Alpine glaciers; that the sediment contained in the Rhine and the Rhone, except such part of it as is washed from the banks along which they flow, is other than Loess? How is it that at Bonn the Rhine water contains no appreciable carbonate of lime as Bischoff has shown? How is it that wherever we can trace deposits directly due to glacial action—*ex. gr.* those being formed at the feet of the Greenland glaciers and the great beds of materials which the glacial age has left in various parts of North Britain and North America consisting of clays of various kinds,—how is it, we say, that nothing in the shape of Loess is to be traced here, but that these deposits in texture, composition, and other characters are quite different from Loess, properly so called? Assuredly there can be but one conclusion, if we reason inductively, namely, that the Loess is not a Glacial mud at all, but had a very different origin. Let us now turn to the several theories of its distribution. First we will consider the lacustrine theory. This view was inspired by the limited area of the Rhine Valley. It was suggested, in fact, that the Loess which mantles that valley and those of its tributaries was deposited by a great lake, banked up by a barrier in the narrow gorge between Bingen and Coblentz. When, however, it was shown that the Loess which existed at Basle and Schaffhausen would necessitate a dam 1,200 feet high to retain the waters of such a lake,—and, further, that the lateral valley of the Lahn was itself filled with Loess,—the difficulty of postulating any sufficient barrier became obvious. But, apart from this, such a lake as was cited to explain the Rhine Loess could not explain its distribution on the flanks of the Carpathians, on the great Polish plain, nor in China. Again, the contents of the Loess are completely against a lacustrine origin. Although it abounds in shells, none of them are lake shells. While the great number of debris of land animals which it contains precludes such an origin. Nor, again, can we understand such a vast *unstratified* deposit accumulating in a lake. The reasons against such a theory are paramount, and since Sir Charles Lyell wrote against it, it has been abandoned both in England and on the Continent. We next come to Lyell's own idea, which he suggested in substitution for the lacustrine theory just quoted. This is still a living theory with some geologists. Lyell suggested that the Loess of the Rhine Valley is of fluviatile origin, and was deposited by the Rhine itself. This notion assuredly makes enormous demands on our credulity. First, the Loess in structure is very different to the warp deposited by a river. Such warp is essentially stratified, and we can trace the annual layers by which it has been deposited; while the Loess is several hundred feet thick, and throughout is homogeneous and unstratified. Secondly, it is so highly charged with carbonate of lime that it is incredible that a river should have deposited it unless its waters were actually saturated with that material. But, as we have said, Bischoff, in 1855, showed that the Rhine at Bonn had virtually no carbonate of lime in it at all. Thirdly, *the contents* of the Loess point strongly to its not being a fluviatile deposit. Sir Charles Lyell argues against its lacustrine origin, because the shells it contains are terrestrial and amphibious. Surely this very argument ought to be conclusive also against its fluviatile origin. The force of this argument is very great, for these shells do not occur locally and sporadically, but in great numbers, and characterize the Loess in China and Eastern Europe, as well as in the Rhine Valley. Let us look more closely at their evidence.

Out of 211,968 shells from the Rhine Loess examined by Braun, there was only one brackish-water form and three sweet-water forms; *Limnæus* and *Planorbis*, with but thirty-two specimens in all. Of the rest there were 98,502 examples of two species of *Succinea*, which is an amphibious species, and 113,434 specimens of land shells belonging to twenty-five species of *Helix*, *Pupa*, *Clausilia*, *Bulimus*, *Limax*, *Vitrina* (Deutsch. Zeits. für die gesammten Naturwiss. Halle, vol. xl. p. 45).

In the Bavarian Highlands Gümbel found one amphibious form (*Succinea*) and 14 terrestrial ones, *Helix*, *Pupa*, *Clausilia* and *Bulimus*. Engelhardt, who has described the Loess of Saxony, refers to 24 localities whence he has examined the shells of the Loess, in which only land and amphibious shells are to be found, while in two only did he find the fresh-water form *Limnæus truncatulus.* Similar land shells are found in the Loess of the Danube Valley of Lower Austria, Hungary, the Carpathians, and Poland.

Mr. Belt tells us that he examined the Loess in the valleys of the Rhine, Main, Danube, and the steppes of Southern Russia, yet he had never seen a fragment of a river-shell.

Baron Richthofen expressly says of the Chinese Loess: "The land shells are distributed throughout the whole thickness of the Loess; and their state of preservation is so perfect that they must have lived on the spot where we now find them" (Journ. Geol. Soc. vol. xxvii. p. 377, note).

The well-known French missionary in China, David, who has done so much for the Natural History of that Empire, speaking of the Loess in the valley of the Yellow River and in North-Western China, says: "I never saw a trace of an aquatic shell in it, but merely the remains of certain small species of *Helices,* many of which exactly resemble those still living in the country." These shells, he says, are found at different depths, but chiefly in the upper part of the formation (Journ. etc., vol. i. p. 93). We may take it, therefore, as an absolute feature of the Loess that it contains virtually no river shells; for, as Mr. Belt says, the *Limnæus truncatulus* had its habitat most probably in small meres rather than in a river.

What is the inference from this? Why, surely, that the deposit which we are discussing is not a fluviatile deposit at all; for, as Mr. Belt says, all our larger rivers abound in shells. The shells of the Loess are not only land shells, but they are shells loving the deep shade of trees and the damp recesses of woods, which woods could not exist where the banks of a river were continually depositing warp on a great scale. Nothing can be argued from the amphibious forms, the *Succineas;* for, as Lyell most frankly says, the shell is not strictly aquatic, but lives in damp places, and may be seen in full activity far from rivers, in meadows where the grass is wet with rain or dew (Antiquity of Man, p. 375). The other contents of the Loess tell the same story; both the animal remains and the relics of man, including the Palæolithic implements which are found in the Loess, and their presence is most inconsistent with the fluviatile origin of the deposit. As we have shown, they occur as nearly as may be under precisely the conditions which exist in Siberia. We could imagine in a narrow rapid river that carcases of Mammoths, etc., might be borne along and be overwhelmed and covered with gravel and other *débris* if they stopped at any point and thus formed a barrier to the flow of the water. But how, in the case of a slow river—much slower than the present Rhine—which is Lyell's own postulate—these remains as they are found at Cannstadt and elsewhere, could be covered over and preserved in skeletons and in hecatombs, without dispersal by gradually accumulating annual layers of warp, is difficult to imagine. Why, again, primæval man should amuse himself by sowing specimens of his flint tools at intervals in the warp of the river, or in the river itself, is equally hard to realize.

If we turn from the contents of the Loess to its distribution, we shall be compelled to the same conclusion. In the first place, then, it occurs quite independently of the drainage of the country. It covers the plateaux as well as the flanks of the valley. The river that could overflow these plateaux has surely ceased to be a river. How, by any mechanical theory, can we account for the water of a slowly moving river with a small fall, even with the greatest winter floods, depositing such masses of Loess, not only 600 feet above its present level, but choking its own lateral valleys up to their very heads with it? What possible river could have deposited the Loess of Poland, or the far more important Loess of China, 6,000 feet above the sea-level? Assuredly, in every way we view the problem, the fluviatile origin of the Loess seems incredible. Which ever way we view the fluviatile origin of the Loess, the difficulties of the explanation are overwhelming. Professor A. Geikie, Mr. Belt, and others have more recently than Lyell started another theory, which virtually amounts to a combination of the fluviatile and lacustrine views. According to them, the waters of the Rhine and other rivers flowing northwards were dammed back by a *mer de glace* occupying the North Sea, and thus made to overflow their upper reaches, like the Obi does now. This theory has all the objections which have been urged against the lacustrine and fluviatile origin of the Loess, with some additional ones. How is the Loess of the Danube Valley and of Hungary, and more especially that of China, to be explained by such a bringing down of the Glacial period almost to our own day? Where was the *mer de glace*, and where the rivers which were dammed back so as to deposit those vast masses of Loess on the Chinese plateaux 6000 feet above the sea-level? How, again, with the proposed *mer de glace* in the North Sea, involving a climate like Greenland or the Polar shores of Siberia, could the Mammoth and his contemporary, the Hippopotamus, could the *Ficus carica* and the *Cyrena fluminalis* have lived in Northern France and Germany? These objections seem to us overwhelming.

We are, therefore, bound to discard this modification of the older hypotheses, and to conclude that every theory requiring a marine, lacustrine, or fluviatile origin for the Loess is inconsistent with the evidence. Let us now turn to another theory, which has received the sanction of Richthofen and Pumpelly in China, and has been indorsed by Professor Ramsay, namely, that the Loess is a subaerial formation. Richthofen's position may be best stated in his own words. "Unbiassed observation," he says, "leads irresistibly to the conclusion that the Loess of China has been formed on dry land. The whole of that vast country, which was covered by a continuous sheet of Loess before this had undergone destruction, was one continuous prairie, probably of greater elevation above the sea than the same region is now. The Loess is the residue of all inorganic matter of numberless generations of plants that drew new supplies incessantly from those substances which ascend in moisture and springs, carried in rotation to the surface. This slow accumulation of decayed matter was assisted by the sand and dust deposited through infinite ages by winds. The land shells are distributed through the whole thickness of the Loess; and their state of preservation is so perfect that they must have lived on the spot where we now find them. They certainly admit of no other explanation than that here hinted at, of the formation of the soil in which they are imbedded. The bones of land animals and chiefly the roots of plants, which are all preserved in their natural and original position, give corroborative evidence" (Journ. Geol. Soc. vol. xxvii. p. 377 note).

The main position of Richthofen is indorsed by Professor Ramsay, who, in speaking on Mr. Kingsmill's paper, is reported to have said that he "thought the phenomena (of the Loess) were rather in accordance with a long exposure of the land to subaerial influences than with the Loess having been of marine origin. Even in England, in those parts which had long been free from marine action, beds of brick-earth had been formed. He also instanced the plains of Picardy as exhibiting a vast extent of such subaerial beds" (Journ. Geol. Soc. vol. xxvii. p. 383).

This theory has one advantage over the others, that it is not immediately answered by an appeal to the contents and structure of the Loess; but its plausibility disappears on a closer acquaintance. As the Père David urges, we ought to meet elsewhere, in districts which have not been denuded, with deposits of a similar character, if this be the remains of the old land surface; but subaerial deposits composed as this is are nowhere, so far as we know, being formed now. But there is a more fatal objection, stated very clearly by Mr. Kingsmill, who says, "Its chemical composition, consisting as it does, mainly, of silicates of alumina and of fine silica, in the condition of impalpable sand, does not correspond with that of the inorganic elements of plants growing on its surface. Granting, however, that the earthy carbonates and a portion of the silica could be derived from such a source, whence could the plants themselves derive these elements, but in turn from the soil on which they grew? Lime, potassa, magnesia, iron, and silica, might, then, so long as the plant had access to the subjacent formations, or was supplied by springs from below, have been deposited in a superficial layer; silica might even, as has been suggested, have been conveyed by the medium of dust storms; but whence could the silicate of alumina be derived? A superficial layer not altogether dissimilar might, as suggested, be formed so long as the plants had access to subjacent rocks. Once, however, removed from contact with them, these inorganic elements of the plants could only be supplied from the rock itself. Rivers are inadmissible, as their action would have been to disintegrate, not to build up; springs, from the peculiarities of the formation, cannot rise to its surface. There is finally no known means by which these inorganic matters could have been supplied from the atmosphere. The layer formed by one generation of plants would in effect have been absorbed by the next without any addition being possible" (Journ. Geol. Soc. vol. xxvii. pp. 380–1). Baron Richthofen's position would be plausible if it were beyond question that the minute ramifying tubes which are found throughout the Loess were the relics of roots of grasses, but this is a mere hypothesis, and one which is by no means probable. That a succession of plants growing in one area for ages should have left no *débris* but these fine tubes, and that they should occur throughout great thicknesses of Loess, where it is 500 and 600 feet in depth, seems quite incredible; and I am more than inclined to accept Mr. Geikie's tentative opinion when he says, "I am not aware that any trace of vegetable matter has ever been found in the tubes, and the capillary structure, like the concretions, may be of inorganic origin. Chemical analyses, at all events, have shown that Loess contains little or no organic matter, which we might have expected to meet with in much greater abundance had plants given origin to the innumerable vertical pores which are so commonly present in the typical deposit of the Rhine and the Danube" (Prehistoric Europe, p. 237). Again, the fact that the Loess is deposited with singularly uniform composition and structure, independently of the nature of the subjacent rocks, shows that if *in situ* and not largely transported, it is entirely different from other subaerial soils which partake of the local characteristics of the rocks on which they rest. The fact is, the more we examine this solution, the more impracticable it becomes. By a process of exhaustion we have pretty nearly sifted every possible source for the Loess.

(*To be concluded in our next Number.*)

ERRATA.—GEOL. MAG. Dec. II. Vol. VIII. p. 569, last line, *for* "merely" *read* "surely"; p. 572, line 10, *for* "with honouring" *read* "in honouring."

## IV.—ON THE TWT HILL CONGLOMERATE.

By Prof. T. G. BONNEY, M.A., F.R.S., F.G.S.

SINCE the date of my communication to the Geological Society on the sections at and in the neighbourhood of Twt Hill,[1] I have more than once visited the district, and have spent much time in working over the specimens which I have collected. The exact relation of these conglomerates to the granitoid rock on which they rest is a matter of great importance as bearing on theoretical questions relating to metamorphic changes in stratified rocks—questions at which for the last three or four years I have lost no opportunity of working. I should therefore, in all probability, have recurred to the subject, even if my attention had not been directed to it by my friend Dr. Roberts' communication and criticism of the above paper.[2] In the latter, it may be remembered that we assigned the Twt Hill conglomerate to the granitoid series. The reasons which led myself, at any rate, after much consideration, to the conclusion, were chiefly the following:—

1. That after very careful examination in the field I was unable

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[1] Written conjointly with Mr. Houghton, Quart. Journ. Geol. Soc. vol. xxxv. p. 321.
[2] See GEOL. MAG. Vol. VIII. Dec. II.

to detect any line of demarcation between the undoubted granitoid beds and the conglomerates.

2. That in no instance had I been able to find fragments of felsite in the conglomerate, though these abound in the undoubted Cambrian conglomerates; and yet near Port Dinorwic beds, probably of the same age as those at Twt Hill,[1] occur close to the felsite, which also in this place appears more probably intrusive in than overlain by the conglomeratic series.

3. That although the metamorphism of the matrix of the conglomerate was much less than in the granitoid rock (and in the schist series of Anglesea), yet it seemed greater, especially in the lower and more felspathic band of the Twt Hill conglomerate than is usual in the true Cambrian conglomerate; while such beds as the Torridon Sandstone, the Quartzite and the "Upper Gneiss" series of the N.W. Highlands, show how much influence the constitution of a rock has had on the amount of metamorphism produced.

Thus, although I fully felt the difficulties, being especially troubled by the presence of schist in the conglomerate, I considered the weight of evidence to be in favour of my conclusion. I may say that while each visit to the section made me more confident of the correctness of my view, each revision of the whole question in my study made me more doubtful of it. The same question also has been constantly present to my mind during my work among metamorphic rocks in the Alps; but as conglomerates and even grits appear to be singularly rare in these, the direct evidence which I have obtained has been but slight, and in no way conclusive on either side.

Dr. Roberts was led to a conclusion opposite to ours, viz. that the beds were much posterior to the granitoid rock, by the following considerations:—

1. That he thought he could see a demarcation in the Twt Hill pit between the conglomeratic series and the granitoid rock.

2. That near Llanerchymedd in Anglesey, a conglomerate, which macroscopically closely resembles the Twt Hill rock, occurs in sequence with fossiliferous Cambrian beds.

3. That this conglomerate consists of "pebbles of quartz imbedded in a felspathic matrix," which removes the "only strong *à priori* argument, viz. the absence of felsite pebbles."

As regards the validity of this reasoning, I need only point out that it is dangerous to infer the identity of these old rocks without a more thorough examination of their microscopic structure than Dr. Roberts appears to have bestowed upon them; and that a presumed identity of beds in localities many miles apart is not a very conclusive argument. Indeed, the presence of felsite pebbles in the one and not in the other would be an argument (if for anything) rather against than for such an identity, to which I may add that "a felspathic matrix"—a conveniently vague term—is not to my mind identical with "fragments of felsite." Why did not Dr. Roberts look for these in the outcrops near to Port Dinorwic, which have far more bearing on the question? So far as I can discover from his paper, he has left them unvisited. Nevertheless, in a matter where the evidence before one can only be imperfect, it is possible to get sometimes to a right conclusion by a wrong method, and sometimes to a wrong conclusion by a right method; and in this case I must frankly confess that, while repudiating Dr. Roberts' arguments, I admit the substantial correctness of his conclusion as regards the Twt Hill conglomerate. I have, however, altered my views for reasons which are more satisfactory to my own mind than any which he has advanced. They are: (1) because from prolonged study of the microscopic structure of metamorphic rocks, I have become more doubtful of the possibility of two such beds as the granitoid rock and the conglomerate belonging to one series; and (2) because I have at last found felsite fragments in the conglomeratic series *in the Carnarvon district.*

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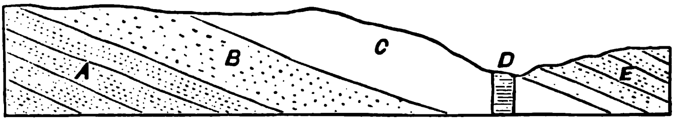
[1] I have admitted this point, of which I was at first doubtful. See this MAGAZINE, Vol. VII. Dec. II. p. 300.

In September, 1880, Mr. Houghton conducted me to a pit (found by him subsequent to the date of our paper) which afforded the section diagrammatically represented below, about half a mile S.S.W. of Tan-y-maes. It is at a spot on the map about two-tenths of an inch south of the first C in Cefn Cynryg, and there can be little doubt of its belonging to the same series as the grits near Careg Goch and Tan-y-maes.



Diagrammatic Section of Pit near Cefn Cynryg.

I copy the annexed description from my note-book:—"The lowest beds visible (*a*) are distinctly bedded quartz-grits or quartzites containing sometimes quartz pebbles up to the size of very small peas; then the grit becomes a little more felspathic and passes through an intermediate stage (*b*) into a band about half a yard thick, which is a quartz-felspar crystalline-looking rock (*c*), not unlike that of Twt Hill, but which on the weathered surface, and sometimes even on the unweathered, shows now and then distinct little quartz pebbles in size from a hemp-seed to a small pea. Then comes a greenstone dyke (*d*)—very rotten—about a foot or so thick, on the other side of which the rock is again a distinct grit (*e*)." The dip is roughly 35° S.S.E. Specimens were selected from all these beds and cut for microscopic examination. I fondly hoped that bed (*b*) would give me the evidence for which I had long been seeking and establish the correctness of my conclusion as to the Twt Hill group, besides supplying me with helpful matter as to other work. I regret to say that—exactly as sometimes happens with the felsite itself—the granitoid aspect proved illusory, and in the slide I found one or two small fragments that I must recognize as felsite (*i.e.* devitrified rhyolite) and identify, so far as one can venture to do this, with that of the mass which begins near Port Dinorwic.

This is to my mind a conclusive argument, and Dr. Roberts may exclaim, *Suo sibi gladio hunc jugulo*; for I should certainly have declined to die by his weapon. The lesson, however, is a valuable one, for it shows how cautious it is needful to be in dealing with these ancient rocks, and above all it proves the impossibility of settling questions relating to them without a thorough microscopic study. It was trusting too much to my eyes in the field (though they were perhaps not less experienced than those of Dr. Roberts), and refusing for this reason to listen to certain doubts suggested by my microscope, which led me wrong, as it has done other observers; it was my microscope, and that alone, which set me right; for on the afternoon when I left the section near Cefn Cynrig I fully thought I should obtain from the rock a verdict in my favour.

From every point of view the rarity of these felsite fragments is very singular at Tan-y-maes. Where the two rocks are almost in contact I have not yet discovered them;[1] yet in all the other conglomerates over a wide area in the Bangor-Carnarvon district they abound. I may add that I prefer at present to regard the exact age of these Twt Hill conglomerates as uncertain. There is no doubt much to be said in favour of regarding them as a local development of the Cambrian conglomerate; but, as I am convinced this is not the only one in the district, there is something to be said in favour of assigning them to a rather earlier date. The matrix certainly is more altered than is usual with the true Cambrian beds.

But, while abandoning the view expressed in the paper, written conjointly with Mr. Houghton, as to the Twt Hill conglomerate, I wish to state distinctly that I do not recede from the opinion expressed in the preceding communication[2] and in this MAGAZINE,[3] as to the age and relation of the various conglomerates on the north-eastern edge of the felsite in the vicinity of Bangor. The whole of that district was again worked over, last year, with the result of obtaining much additional evidence and unhoped-for confirmation of my views as to the presence of a considerable series of beds (conglomeratic, slaty, etc.) between the felsite and the true Cambrian conglomerate. As regards this district, and as regards the opinion expressed concerning certain rash and unscientific generalizations about the Anglesea schists, I adhere to the views which I have already published, and may hereafter ask permission to give my reasons.[4] It will, however, be some time before the whole of my collection can be unpacked and settled in its new quarters, so I have thought it better not to delay longer the admission of the one point where I find that I have erred.

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[1] Further examination of specimens makes me doubtful if this is more than an accident owing to the state of the rocks; for I find some rotten fragments which may be felsite. Hence the section at Tan-y-maes (figured on p. 301, of Vol. VII. of this MAGAZINE) does not bear out the conclusion which from it seems more probable. I may also mention that I find from further examination that all the rock exposed in the bank under the cottage gardens is a spherulitic felsite.

[2] Quart. Journ. Geol. Soc. vol. xxxv. p. 309.

[3] Dec. II. Vol. VII. p. 298.

[4] It will be prudent not to accept the "Crug beds" as an upper subdivision of the "Carnarvon series" till they have been further examined. Perhaps it may be found that the felsite has been at some of its old tricks in this district also.

P.S.—The above remarks were written before the October Number of the Magazine, containing Dr. Roberts' second paper, had reached me. I leave them as they were written, though he appears now to have visited the Port Dinorwic district, and distinctly speaks of felsite pebbles in Anglesea, because his examination of the former does not seem to have been careful enough to show him that the grits become conglomeratic near Tan-y-maes, and I do not admit that the question can be settled by the latter. I have not myself been struck with the remarkable resemblance of the conglomerate of Garth Ferry to that of Twt Hill, and think that by the method of reasoning here adopted I could prove even the Bangor series of Prof. Hughes to be only Cambrian conglomerate.—T. G. B.

## V.—Contributions to the Palæobotany of Sweden.[1]

By Wm. Carruthers, F.R.S., F.L.S., F.G.S.

Mr. A. G. NATHORST, whose recent contributions to the Palæobotany of Sweden have been very valuable, has been turning his attention to the impressions found on the surface of schists, especially in Palæozoic rocks, which have been too readily accepted as impressions of plants. They find a place among the Algæ of Schimper's "Traité de Paléontologie Végétale," and they are employed by Saporta and Marion in their recent work, "L'Evolution du Règne Végétal," and are treated as Algæ, and employed as data in their account of the evolution of the vegetable kingdom. Mr. Nathorst, so long ago as 1873, called in question the plant origin of many of these markings, and he has recently published in the Transactions of the Royal Swedish Academy (vol. xviii. No. 7, Stockholm, 1881) an exhaustive treatise on the subject, with eleven phototypic plates of impressions which he obtained by the motions of different animals or the trails of plants on soft materials. He first experimented with gypsum, getting the animals to move over the surface while it was soft, and securing the permanence of the tracks by the hardening of the gypsum. This method was satisfactory with the smaller crustacea, but annelids and molluscs moved so slowly that the gypsum hardened before they crossed it. And, besides, it was not possible to experiment in this way with some marine animals, for the fresh water with which the gypsum was mixed at once killed them. The earlier plates are devoted to the impressions produced on the soft gypsum. The results are remarkably like the *Arthrophycus* and *Crossochorda* of the Silurians. These impressions have been produced by the following Crustacea: *Corophium longicorne*, Fabr., *Crangon vulgaris*, Fabr., *Jæra albifrons*, Leuck., *Gammarus locusta*, Linn., and *Idothea baltica*, Pall. The markings made by the *Idothea* are singularly like the impressions of a Lycopodium, or of some branching sea-weed, like *Caulerpites*, Sch.

[1] Om Spår af Några evertebrerade djur MM. Och Deras Paleontologiska betydelse, af A. G. Nathorst, med 11 Taflor, 4to. pp. 60.
Kongl. Svenska Vet. Akad. Handl. Band. 18, No. 7. Stockholm: 1881.

Nicholson and Etheridge had given a similar explanation of *Crossopodia*, and other *Nereites* markings in their valuable contribution to Silurian Palæontology (see their Monograph of the Silurian Fossils of the Girvan district, pp. 304–318).

Mr. Nathorst further experimented with fine mud obtained from a depth of 12 to 15 ft., and which he placed, with all the animals contained in it, in vessels of different depths. It was remarkable how speedily after the vessels were at rest a great multitude of very different tracks were produced. It became obvious that the sea-bottom, where it consists of fine sediment inhabited by animals, must be completely covered by trails of different kinds. The most curious specimens procured were the trails of *Goniada*, *Glycera*, and some other annelids which were found to be *constantly branched* as in the impressions referred to the genus *Chondrites*. The impressions, which are reproduced with minute fidelity and beauty in the phototypes, were fixed by pouring liquid gypsum over the wet mud, a method which Mr. Nathorst found to succeed in preserving the most delicate markings. The trails of the annelid *Goniada maculata*, Oersted, are very familiar as Palæozoic "Algæ." In one of the specimens of this creature's work (pl. ix. fig. 1), we find several "plants" springing from one place, that in the centre is more vigorous than the others, and gives off in an *alternate manner* from its main axis a number of branches which are again branched. This is so singularly faithful an outline of some fossil algæ, that nothing short of the testimony of so careful an observer as Mr. Nathorst would convince one that it could have been produced by an animal. The radiating tentacles of a *Terebella* produce a good imitation of a plant. The impressions of an *Amphiura*, which had been lying on the mud with its arms extended, but had gently moved the ends to and fro, gives a branching appearance, with a flabellate outline to the "frond." The trails of molluscs like *Montacuta*, and the larvæ of some dipterous insects, obtained in a garden after rain, are figured, showing long simple markings twisting and turning on themselves, and giving very faithful representations of the impressions referred to *Palæochorda*. The markings made by earth worms supply also very good materials for interpreting some impressions generally treated as species of fossil algæ. Mr. Nathorst's figure on p. 19 may be compared with the figures of *Physophycus marginatus*, Sch., on p. 87 of Saporta and Marion's recent work.

Mr. Nathorst compares in detail, and with great care, the results of his experiments with the list of *Algæ* contained in Schimper-Zittel's "Handbuch der Palæontologie," and finds that all the impressions brought together under the title "*Algæ incertæ sedis*" can be produced by animals or by the mechanical action of plants operated upon by running water. These Palæozoic algæ are mere impressions on the surface of ancient mud, and never exhibit any remains of organic matter. It is very satisfactory to obtain such clear evidence of their true nature, and to get rid of the false genera and species which have unhappily burdened our handbooks, and of the speculations which have been based on these misunderstood markings.

With these must also go the impressions from the Lower Silurians of Sweden which constitute the genus *Eophyton*. These were always known to be only surface markings, but so remarkably did they imitate stems and leaves of plants that it was very difficult to gainsay those who unhesitatingly placed them among vegetables. And if vegetables, it seemed certain that they belonged to Phanerogamous plants, and not to any of the lower groups of Cryptogamous plants whose remains are the earliest vegetable fossils met with. Mr. Nathorst has produced typical specimens of *Eophyton* from the trails of plants over soft mud. So that while *Eophyton* testifies to the existence of life on the shores when the markings were made, these markings supply no evidence as to the nature or form of the plants by which they were produced.

It may be worth while to add a sentence to this notice in order to record that the doubt already thrown on Saporta's Lower Silurian fern *Eopteris Morieri* was confirmed by the examination of a specimen exhibited at a recent meeting of the Geological Society. And that the mineral nature of the markings was completely established, and the impossibility of its being a plant was pointed out by Dr. Sterry Hunt when he showed that it lay along the lines of the slaty cleavage, and not on a surface of deposition.

## NOTICES OF MEMOIRS.

### I.—Om Aftryck af Medusor i Sveriges Kambriska Lager. Af A. G. Nathorst, Kongl. Svenska Vetenskaps-Akademiens Handlingar. Bandet 19, No. 1. Med 6 Taflor. Stockholm, 1881. On Impressions of Medusæ in the Cambrian Rocks of Sweden. By A. G. Nathorst.

In this Number of the Magazine a notice is given by Wm. Carruthers, Esq., F.R.S., of a paper by Herr Nathorst, in which he brings forward reasons to show that the impressions on beds of sandstone of Cambrian age, hitherto regarded as plants, and known under the generic name of *Eophyton*, were more probably markings produced by the trails of Medusæ. In the present paper the author endeavours to prove that the same beds contain impressions and casts of these organisms. The possibility of jelly-fishes leaving proofs of their existence in the rocks is well known from the indubitable impressions left by these animals in the Solenhofen slates. The Eophyton sandstones are, however, much less fitted to receive and retain the markings of delicate organisms than the lithographic beds of Solenhofen, and it is not, therefore, to be wondered at that the impressions they contain, being ruder and more indefinite in their character, should have been variously interpreted. This accounts for the circumstance that the forms now referred by the author to Medusæ have been previously described by Torell and Linnarsson under the generic names of *Spatangopsis*, *Agelacrinus?*, *Protolyellia*, and *Astylospongia*, and thus attributed to Sponges, Corals, Crinoids and Echinoderms! These fossils retain no organic structures, and only the form has been preserved. As regards those described as corals and sponges, such authorities as Lindström and Roemer repudiate their connexion with these groups.

It appears that Herr Nathorst was led to compare these fossils to the impressions of Medusæ by casually observing the similarity of form between some specimens of the existing Medusa, *Aurelia aurita*, thrown up on the beach at Öresund, and specimens of so-called *Spatangopsis* from the Eophyton sandstone at Lugnås, which are in the Stockholm Museum. This similarity induced him to try the experiment of obtaining casts of these existing Medusæ by means of dilute plaster, and the resemblances between the artificial and the natural impressions were so close that the author regards it as proved that the fossil impressions result from Medusæ. The impressions most commonly met with, have the shape of a central, elevated pyramidal body, from which radiate four or five arms or rays. This form has resulted from the settling down of the Medusa into the mud, which, by the infilling of the gastral cavity, has produced the pyramidal body, whilst the radiating impressions are those of the prolonged angles of the mouth. Another form which generally occurs free is believed by Nathorst to result from the infilling of the gastral cavity of those animals which have died or been thrown on the strand with the mouth uppermost.

The author treats at length the various points of comparison between the fossils and existing Medusæ of various families, and refers the forms to three species:—*Medusites radiatus*, Linnars. sp. =*Astylospongia radiata*, pp. Linnars.; *M. favosus*, n.sp=*Protolyellia princeps*, Torell, and *Astylospongia radiata*, pp. Linnars.; and *M. Lindströmi*, Linnars. sp.=*Spatangopsis costata*, Torell, and *Agelacrinus? Lindströmi*, Linnars. In addition to these forms, which are regarded as resulting from the impressions and infillings of the central portions of Medusæ, the author attributes the peculiar spiral casts in the same rocks, named by Torell *Spiroscolex spiralis*, to the tentacles of Medusæ.

In a supplement the author thinks that the life-habits of the existing genus *Polyclonia*, recently described by Profs. Moseley and Agassiz, tend to show further the probability of the Medusa-origin of these fossils. *Polyclonia* lives in great numbers near the muddy bottom of certain seas, and its movements would tend to produce the Eophyton markings, whilst it has also the habit of turning its bell uppermost, and this, in the dead specimens, would facilitate the entrance of sediment into the gastric cavity.

The facts brought forward in this paper indicate at least great probability that the author's conclusions are correct, and he may be congratulated on having carried our knowledge of the existence of these organisms back from Jurassic to Cambrian times.

G. J. H.

## II.—NEW ZEALAND GEOLOGY. Reports of Geological Explorations during 1879–80. JAMES HECTOR, M.D., F.R.S., Director. (Wellington, 1881.)

THE Geological Survey of New Zealand appears to be making good progress. During the season 1879–80 a number of important explorations have been made, so that nearly four thousand square miles have been added to the general mapping of the colony, mostly in the Auckland, Canterbury, and Otago districts.

Full details of these surveys are given by Messrs. Cox and McKay, accompanied by maps, sections, and lists of the fossils collected. In a prefatory chapter or progress report, Dr. Hector summarizes the general results of the work done, and shows the important additions they have made to the knowledge of the geological structure and economical substances of the districts examined, and introduces some remarks on the comparison of the geology of New Zealand with that of Australia, and gives a table of the fossiliferous formations of the two countries.

"On the whole, the geological record, so far as yet known, is more complete in the New Zealand than in the Australian area. The Tertiary strata are perhaps equally well developed, and the distinguishing facies of each existing fauna is discernible as early as the Eocene formations. The Upper Mesozoic formations are very imperfectly represented in Australia, but have enormous development in New Zealand, in which country, as in America, the Tertiary facies of the fauna and flora springs from a shore-line and land-surface of pre-Cretaceous age. This is the period of the chief coal deposits in New Zealand.

"It was in the Lower Mesozoic period that the greatest divergence in the character of the deposits prevailed in the several areas. In Australia marine Jurassic formations, which can be determined by their fossils, are not extensively developed, while the characteristic fauna of the Trias has not yet been detected (with the exception of *Estheria*, recently noticed in the core excavated by the diamond drill from under the Sydney sandstone); fossil plants, which are most uncertain guides, being alone found in the strata which must be referred to that period. In New Zealand, on the other hand, three divisions of the Jurassic formation have been distinguished by their abundant fossil contents. A Liassic formation has a fair development, while an Upper Trias or Rhætic formation has an importance due to thickness and variety of fossils which is unknown elsewhere. The Trias, with its very characteristic molluscan fauna, is largely developed, and also occurs in New Caledonia. Without any marked break the sequence in New Zealand passes down into a thick formation with Permian fossils, but associated with forms found in the Trias, while the more strictly Palæozoic elements of the Permian fauna are absent. This is followed in New Zealand by a gap, and the next formation, which is the Lower Carboniferous and Upper Devonian, is the latest formation, according to our present evidence, which appears to have been common to Australia and New Zealand, and to have been deposited in both areas under the same physical conditions, and within a common biological province.

"The attempt to correlate the lower Mesozoic formations in the two countries is therefore a matter of some difficulty; but as plant-beds occur at intervals, interstratified with the marine strata of New Zealand, these may be perhaps yet employed successfully as indications of relative age.

"This would be a most useful labour, as the strata concerning the age of which there is so much uncertainty are in Australia and India of the highest economic importance from their containing workable coal-seams; but while the Upper Jurassic flora is well developed in New Zealand, and can be successfully compared with that of corresponding age in Australia and India, the lower plant-beds of Rhætic, Triassic, and Permian age have only yielded specimens in a bad state of preservation. The following attempt at a tabular comparison of the age of the formations in the two countries is therefore not made altogether on palæontological evidence, and is only the reading of the Australian record from the New Zealand point of view, so far as the characters and subdivisions of the Australian formations have been described by various authors.

"TABLE OF FOSSILIFEROUS FORMATIONS.

| New Zealand. | Australia. |
|---|---|
| I.—Recent—<br>Moa beds.<br>Alluvia.<br>Volcanic.<br>Shingle plains. | Newer gold drift, scoriaceous lavas of Victoria. |
| II.—Pliocene—<br>Shingle plains.<br>Pumice sands.<br>Lignite beds.<br>Kereru beds. | Older gold drift and deep leads of Victoria. |
| III.—Upper Miocene—<br>Wanganui beds.<br>Awatere beds. | Limestones of South Australian Bight. |
| IV.—Lower Miocene—<br>Ross beds.<br>Mangapakeha beds.<br>Pareore beds. | Portland beds of Victoria, Murray River beds. |
| V.—Upper Eocene—<br>Mt. Brown Beds. | Schnapper Point beds of Victoria. |
| Oamaru beds.<br>Nummulitic beds. | Table Cape, Tasmania. |
| VI.—Cretaceo-Tertiary—<br>Grey Marls. | New Britain? |
| Ototara stone.<br>Fucoidal greensand. | New Caledonia. |
| Amuri limestone.<br>Island sandstone. | Queensland. |

| NEW ZEALAND. | AUSTRALIA. |
|---|---|
| COAL FORMATION OF NEW ZEALAND. | |
| Black grit. | |
| Conglomerate. | |
| Propylite breccias. | |
| VII.—NEOCOMIAN— | Flinders River beds, Queensland. |
| Conglomerates with coal. | New Caledonia. |
| Porphyries. | |
| Greensands. | |
| VII.—JURASSIC. | Queensland, West Australia. |
| Upper— | |
| Matura beds. | Clarence River Coal, N.S.W. |
| Coal seams. | |
| Middle— | Jerusalem coal, Tasmania. |
| Putataka beds. | Rajmahal plant-beds, India. |
| Lower— | |
| Flag Hill beds. | Cape Paterson, Victoria. |
| IX.—LIASSIC— | Queensland? |
| Catlin's River beds. | |
| Bastion beds. | |
| X.—RHÆTIC AND TRIASSIC. | Wianamatta shales, N.S.W. |
| Otapiri beds. | |
| Wairoa beds. | New Caledonia. |
| XI.—PERMIAN— | Hawkesbury sandstone. |
| Upper— | Conglomerate, Lake Macquarie? |
| Oreti beds. | |
| Great conglomerate. | Gondwana series, India. |
| Great sandstone. | |
| Lower— | Newcastle Coal Measures, N.S.W. |
| Mount Potts beds. | |
| Kaihiku beds. | |
| Glossopteris beds. | |
| Conglomerates. | |
| Red Sandstones. | |
| Wanting? | Stony Creek beds and Wollongong beds, N.S.W. |
| XII.—LOWER CARBONIFEROUS. | Port Stephens beds, N.S.W. |
| Maitia slates. | |
| Te Anau beds. | Tasmania. |
| | Gympie Creek, Queensland. |
| XIII.—LOWER DEVONIAN— | Murrumbidgee beds, N.S.W. |
| Reefton beds. | |
| XIV.—UPPER SILURIAN— | Yass and Hume beds, N.S.W. |
| Baton River slates. | |
| Limestones. | Gordon River, Tasmania. |
| Serpentinous slates. | |
| XV.—LOWER SILURIAN— | Auriferous slates of Victoria. |
| Graptolites. | |
| Marbles. | |
| Hornblende rocks." | |

## III.—ON THE STRATA BETWEEN THE CHILLESFORD BEDS AND THE LOWER BOULDER-CLAY. "THE MUNDESLEY AND WESTLETON BEDS." By J. PRESTWICH, M.A., F.R.S., F.G.S., Professor of Geology in the University of Oxford.

(British Association Reports: York Meeting.)

WHERE a particular series of strata presents, in adjacent but conterminous areas, markedly different palæontological and lithological characters, it may be sometimes convenient, as in the case of the "Reading and Woolwich Series," to give them a double geographical term, indicative of the localities where each type is well developed, and its relation to the overlying and underlying strata well shown.

The beds between the Chillesford Clay and the Lower Boulder-clay present such a series. Its exhibition on the coast of Norfolk, although very limited, is accompanied by special palæontological features, that have caused it to be divided into the number of local beds which have been described by Trimmer, Green, Gunn, Wood, and Harmer, the author, Reid, Blake, and others. It includes the "Laminated Clays" of Gunn, the "Bure Valley Crag" of Searles Wood, the "Westleton Shingle" of the author, and the "Rootlet-bed" and "Norwich Series" of Blake. Without reverting at present to the exact correlation of the several beds in the Norfolk area, respecting which there is still some difference of opinion, the author suggests that they should be included under a general term founded on the localities where, on the one hand, their varied palæontological characters are exhibited, and on the other, where their peculiar petrological characters are well marked—characters which the author proposes to show, in another paper, have a very wide range, and serve to mark an important geological horizon in some interesting questions of local physical geology.

The Mundesley beds were described by the author in 1860, and consist of alternating beds of clay, sands, and shingle, some containing freshwater and others marine mollusca, with a forest-growth and mammalian remains at their base; and again in 1871, including them in his Westleton group (No. 5 in the author's sections), which he showed to consist entirely of great masses of well-rounded shingle, with intercalated seams containing traces only of marine shells. Seeing the inconvenience of attaching the same term to the two very distinct series of beds, and that it may conflict with other local terms, the author now proposes to group this series under the term of "The Mundesley and Westleton Beds," indicative of their stratigraphical position in Norfolk, and of characters in Suffolk which serve to trace them in their range westward and inland to considerable distances beyond the Crag area, to which alone these beds have hitherto been restricted. At the same time, it may be convenient, for brevity, to use one term only in speaking of typical cases.

## IV.—SOME OBSERVATIONS ON THE CAUSES OF VOLCANIC ACTION. By J. PRESTWICH, M.A., F.R.S., etc., Professor of Geology in the University of Oxford.

(British Association Reports: Section C. York Meeting.)

CONSIDERABLE difference of opinion still exists as to the cause of volcanic action. The hypothesis, however, generally accepted in this country is that of the late Mr. Poulett Scrope, who considered that "the rise of lava in a volcanic vent is occasioned by the expansion of volumes of high-pressure steam, generated in a mass of liquefied and heated matter within or beneath the eruptive orifice." According to his view, the expulsion of the lava is effected solely by high-pressure steam generated at great depths, but at what depths is not mentioned, nor is it explained how the water is introduced, whether from the surface or whether from water in original combination with the basic magma.

The objections to this hypothesis are—1st. That during the most powerful explosions, *i.e.* when the discharge of steam is at its maximum, the escape of lava is frequently at its minimum.

2ndly. That streams of lava often flow with little disengagement of steam, and are generally greatest after the force of the first violent explosion is expended.

3rdly. That it is not a mere boiling over, in which case, after the escape of the active agent—the water—and the expulsion of such portion of the obstructing medium, the lava, as became entangled with it, the remaining lava would subside in the vent to a depth corresponding to the quantity of lava ejected; but the level of the lava, *cæteris paribus*, remains the same during successive eruptions. Of the important part played by water in volcanic eruptions there can be no doubt, but instead of considering it as the primary, the author views it as a secondary cause in volcanic eruptions.

All observers agree in describing ordinary volcanic eruptions as generally accompanied or preceded by shocks, or earthquakes, of a minor or local character, to which succeed paroxysmal explosions, during which vast quantities of stones, scoriæ, and ashes, together with volumes of steam, are projected from the crater. The first paroxysms are the most violent, and they gradually decrease and then cease altogether. The flow of lava, on the other hand, which commences sooner or later after the first explosions, is continued and prolonged independently. Ultimately the volcano returns to a state of repose, which may last a few months or many years.

Adopting the theory of an original igneous nucleus, but without going into the controverted question of the present state of that nucleus and the outer crust, the author considers a certain fluidity of the former, and mobility of the latter, or of a portion thereof, to be proved by the facts of the case. The one and the other feebly represent conditions of which the phenomena of the rocks afford clearer and stronger evidence as we go back in geological time. Although thermometrical experiments of the necessary accuracy and length of time are yet wanting, it has been estimated that a small quantity of central heat still reaches the surface and is lost by radiation into space. Besides, it is evident that even the escape of liquid lava and steam from volcanos, and of hot springs from these and other sources, must bring, in however small a quantity, a certain increment of heat from the interior to the surface, where it is lost. This should lead to a certain contraction at depths, and of re-adjustment of the external crust, in consequence of which the fused masses of the interior will from time to time tend to be forced outwards, whenever tension became sufficient to overcome resistance. In this the author agrees with many other geologists. The further hypothesis respecting volcanic action which he now suggests, he has, however, been mainly led to form by his researches on underground waters, and may be stated in a few words as follows :—

A portion of the rain falling on the surface not only of permeable and fissured sedimentary strata, but also of fissured and creviced crystalline and other rocks, passes below ground, and is there transmitted as far down as the permeable rocks range, or as the fissures in the rocks extend, unless some counteracting causes intervene. Those causes are the occurrence of impermeable rocks, faults, and heat. The former two are exceptional, the latter constant. The increase of temperature with depth being 1° Fahr. for every 50 to 60 ft., the boiling-point of water would be reached at a depth of about 10,000 ft., but owing to the pressure of the superincumbent rocks, it has been estimated that water will retain its liquidity and continue to circulate freely to far greater depths. Unfortunately, very little is known of the substrata of volcanos. Etna and Hecla apparently stand on permeable Tertiary strata, Vesuvius on Tertiary and Cretaceous strata, while in South America some of the volcanos are seemingly situated amongst Palæozoic and crystalline rocks. Under ordinary circumstances, all the permeable strata and all fissured rocks become charged with water up to the level of the lowest point of escape on the surface, or if there should be an escape in the sea-bed, then to that level, *plus* a difference caused by friction.

The extreme porosity of lavas is well known. All the water falling on the surface of Etna and Vesuvius (except where the rocks are decomposed and a surface soil formed) disappears at once, passing into the fissures and cavities formed by the contraction of the lava in cooling. Not only are these fissures filled, but the water lodges in the main duct itself, and occasionally rises to a height to fill the crater. Beneath the mass of fragmentary and cavernous volcanic materials forming the volcano, lies the original compact mass of sedimentary strata, etc. Owing to the fortunate circumstance of an artesian well having been sunk at Naples, we know the underlying sedimentary strata there to consist of alternating strata of marl, sands, and sandstones, some water-bearing, others impermeable. The water from the lowest spring reached in this boring, rose at first 8 feet above the surface, and 81 feet above the sea-level. Where the strata crop out in the sea-bed, the same pressure of the column of inland water forces the fresh water outwards, so as to form a fresh water spring in the sea, as at

Spezzia and elsewhere on the Mediterranean coast. It is this fundamental hydrostatic principle which keeps wells in islands, and in shores adjacent to the sea, free from salt water, as in the Isle of Thanet. Where, however, the head of inland waters is small or impeded, sea-water will enter the permeable strata, and spoil the springs, as in the case of the Lower Tertiary Sands at Ostend, and the Lower Greensand at Calais and in the Somme, in which latter department the underground spring was found affected to a distance of about 1 mile from the sea, but pure at a distance of 9 miles. Further, if where the head of inland water is sufficient to force back the sea-water under ordinary conditions, these ordinary conditions are disturbed by pumping to an extent that lowers the line of water-level to below that of the sea-level, then the sea-water will flow inwards until an equilibrium is established. The flow of water under a volcanic mountain may be also influenced by the quaquaversal dip, which there is some evidence that the underlying strata there take, owing probably to the removal of matter from below, and the weight of the mountain. If we are to assume that the volcanic ashes and tufas below Naples are subaërial, the original land-surface has sunk not less than 665 feet, and a dip of the underlying strata from the seaward, as well as from inland, has in all probability been caused. This artesian well was carried to the depth of 1524 feet, and passed through three water-bearing beds —one in the volcanic ashes, the second in the Sub-Apennine beds, and the third in the Cretaceous strata at the bottom.

When undisturbed, the underground fissures and cavities of the volcanic materials forming a volcano must soon become filled by the infiltration of rain-water from the surface, while the strata on which they rest are charged, or not, with water, according as they are permeable or impermeable — following the usual laws affecting underground waters. No eruption of lava can then take place without coming in contact with these underground waters. The first to be affected will be the water in the cavities of the mountain in and around the crater. As the pressure of the ascending column of lava splits the crust formed subsequently to the preceding eruption, the water finds its way to the heated surface, and leads to explosions more or less violent. When the fluid lava breaks more completely through the old crust, and the mountain is fissured by the force and pressure of the ascending column, the whole body of water stored in the mountain successively flows in upon the heated lava, and is at once flashed off into steam. Then take place those more violent detonations and explosions—those deluges of rain arising from the condensed steam—with which the great eruptions usually commence. As the more superficial waters of the superincumbent lavas and ashes are exhausted, the springs in the deeper underlying strata, cut through by the fissures in which the main ducts are situated, come into play, and varying with the pressure consequent on the rise and fall of the column of lava, discharge their contents more or less rapidly into those ducts, where, when they reach the point, when pressure permits, they flash into steam and rise in vast bubbles of vapour to the surface of the land. Of the quantity of this underground water some notion may be formed by the fact that the deepest of the three springs under Naples discharged, when first tapped, two cubic mètres (430 gallons) per minute. The water may pass in bodily in consequence of the powerful shocks and vibrations shaking and breaking the strata, and so causing masses of rock to fall in from the sides of the main duct, accompanied by the water held in the beds, or it may pass in by capillarity, for it is well known that this state exercises a remarkable influence on the conditions of equilibrium on the two sides of a porous body, and Mr. Daubrée has shown that water will pass through sandstone notwithstanding the stronger resistance of steam. The experiments were only carried to the extent of a steam-pressure of two atmospheres, but it was evident that the limits of the power were not reached. They further also showed that heat materially increased the power. There is reason to suppose that water, under the considerable hydrostatic pressures that exist beneath volcanic mountains, and assisted by capillarity, may flow into the volcanic ducts with facility, especially when aided by the intermittent relief of pressure, afforded by the rise and fall, or pulsations, of the column of lava.

As the underground springs fed by the rainfall are exhausted by the expulsion of the large volumes of water converted into steam, another agent comes into operation. The surplus water, one portion of which usually goes to feed the surface springs, while another portion passes through the permeable strata into the sea-bed, is not only removed, but the level of the underground waters in the sedimentary strata is so lowered that the hydrostatic pressure is no longer equal to that exercised by the column of sea-water, so that, instead of an outflow from the land, an inflow from the sea necessarily takes place through the same channels or strata, and thus, taking the place of the displaced fresh-water, finds it way to the volcanic ducts. It is only when from the exhaustion of the fresh-water sources and the impeded access of sea-water, whether owing to the resistance of the strata or to a decreasing hydrostatic pressure, that the lava flows quietly and unaccompanied by the violent explosions which mark the commencement of an eruption. If, on the other hand, the sea-water gains access more freely through the more porous volcanic materials, as in Stromboli and Kilauea, a constant volcanic activity may be maintained. In ordinary cases, however, where the inland waters, after the force of the eruption is expended, regain the ascendant, they again exclude the sea-water, and return to a state of equilibrium, which lasts until the strata are again disturbed and fractured by a renewed eruption of lava.

In conclusion, the author conceives that the first cause of volcanic action is the welling up of the lava in consequence of pressure due to slight contraction of a portion of the earth's crust. Secondly, the fluid lava coming into contact with water stored in the crevices of the masses of lava and ashes forming the volcano, the water is at once flashed into steam, giving rise to powerful detonations and explosions. Thirdly follows an influx of water from the underlying sedimentary or other strata lying at greater depths into the ducts of the volcano; and, lastly, as these subterranean bodies of water are thus converted into steam and expelled, the exhausted strata then serve as a channel to an influx of sea-water into the volcano. A point is finally reached when, owing to the cessation of the powerful shocks and vibrations, and the excessive drainage of the strata, the flow of the lava is effected quietly, and so continues until another equilibrium is established and the lava ceases to escape.

## REVIEWS.

ILLUSTRATIONS OF THE EARTH'S SURFACE. GLACIERS. By PROF. N. S. SHALER and W. M. DAVIS. 4to. pp. 198; 26 Plates. (Boston, 1881: J. Osgood & Co.).

THIS volume, which, according to the preface, is designed for students, is presented to us with such a luxury of appearance, and wealth of illustration, that only an affluent publishing house could display. It forms the first of a series destined to portray the actual features of the earth's surface under the action of geological agencies by means of sun-pictures, together with an explanatory commentary. The idea seems to us a happy one. In the present case advantage has been taken of the admirable views of Swiss glaciers which are to be had, owing to the enterprise of photographers, to place a selection of them reproduced by the heliotype process before students and the geological public; such being chosen as are most typical of glacial phenomena. A few from India, Colorado, Norway, etc., are also included.

We do not imagine that the book will be confined to students in the ordinary sense of the term; it is suitable for and will doubtless be found on many a drawing-room table. That large part of an intelligent public who go again and again to Switzerland to revel in the fascination of snow and ice scenery, will find in the views of familiar glaciers what will bring the original scene vividly before them, while in the letterpress and descriptions are pointed out details which, perhaps, they did not notice, and of which, now, for the first time, they see the meaning and importance.

All know that a glacier moves; their guides will not fail to tell the tourist that, and, indeed, this fact was known to dwellers in the mountains before scientific men paid any attention to it. In the twelfth chapter the growth of our knowledge on the subject of Glaciers is passed in review, for, to use the author's words, "the student of nature will find that the best way into any science is through the history of the discoveries that have made it a science." In the opening chapter the physical phenomena are described; in the first place, those of the existing Swiss glaciers; the grotto at the lower end whence issues the stream of water, milky-white, from the abraded mud, which has been the result of friction of the ice or of stones imbedded in it like graving tools—the dirt bands, moraines, crevasses, seracs, all which are exemplified in the heliotypes. Woodcut diagrams are also added in the letterpress. From Switzerland the author passes to Greenland, describing what is known of glaciers there, and their icebergs. They seem to differ in many things, among others the comparative absence of moraines.

The consideration of ice-floes of polar coasts and the Palæochrystic sea leads to a speculation, in opposition to the views of geographers, that "the Antarctic continent is nothing but an immense sheet of ice, such as the Palæochrystic sea would become if it were to increase in depth until it fastened to the bottom of the sea. Given a vast sheet of ice wrapping the surface of a circum-polar sea, supposing it to grow from winter cold and snow more rapidly than the melting of the water could remove it, the result would be that the ice-sheet would in time cleave to the bottom of the sea, and become a true glacier, although any portion of its bed was below the level of the water." In favour of this hypothesis, is cited the southward pointing of the southern continents and the gradual falling out of land towards the South Pole.

The distribution of existing glaciers, of former ones, and of glacial drift, is shown by a map specially drawn for this purpose; we notice that no signs of any approach the tropics, while it is stated in the text that L. Agassiz withdrew the suggestion that he once hazarded about remains of glaciation in the Brazils. It is claimed for North America that it shows the most extensive development of glaciation; that both in size and in their effects the glaciers were more massive and powerful than those of Europe. The contrast here drawn will be of interest to European readers. In Europe the Glacial Period brought no general ice envelope except in its most northernmost parts, but in North America quite other conditions prevailed: here the ice lay as a continuous mass stretching down from the polar regions to the central parts of the continent, overlapping the shores for a great distance to the south along the coasts, and giving a continuous though irregular ice-front across the land from sea to sea. This line as well as the direction of glacial striæ over the north of the continent is laid down on a second map. To this continuous glacier face our author boldly ascribes the origin of numerous rock-basins. The surface of this region is said to be worn into the peculiarly uneven surface that glaciers alone can produce. Of the myriad lakes that lie in the hollows of this uneven face the maps show but a fraction. It is asserted that running water could never carve a lake-basin in such rocks as occupy this region, while ice is the only competent agent to do it. Great force must be given to the argument drawn from the fact that rock-basins only exist in abundance where glaciers have been at work, and in New England their long axes lie so constantly in the direction of the flow of the ice that it is said the Indians in thick weather used these lines of direction as a means of telling the position of the North. As far as the thickness of the ice is concerned, it is indicated by the following considerations: the ice is said to have completely covered Mount Washington, which is about 5000 feet above the neighbouring table-lands on either side. Yet the ice must have been deep enough over the summit to cause the current to disregard the obstacle, for in the case of this and other hills the glacial striæ pursue a straight course up the northern and down the southern flanks. If the mountain had only been buried for a slight depth below the ice, the glacier would have been deflected to either side. The conclusion is therefore drawn that the ice was more than a mile in depth.

When, however, an explanation has to be given of the movement of the ice-spread, great difficulties are met with; our author has, however, the courage of his convictions. These difficulties are enhanced by the circumstance that there is no slope down which the ice could have flowed, in fact there is proof of a depression to the north in glacial times. This depression has only been studied in detail on the coast; "at its southern extremity it was only 20 ft.; at Boston it seems to have extended up to fifty or eighty feet; on the coast of Maine it was near 300 ft. In the valley of L. Champlain it was as much as 350 ft.; in Labrador it seems to have attained 1000 ft., and in Greenland there are reasons for thinking it amounted to over 2000 ft." Granting this subsidence, which is candidly insisted on by the author, the difficulty of explaining the motion of the ice-sheet by the action of gravity is well-nigh insuperable. "The only way in which gravitation could be brought to act under these circumstances would be by the heaping up of the ice in the northern regions to so great a height that the slope of the upper surface to the south would be as great as that which suffices to impel ordinary glaciers down their declivities." Certainly the thickness would have to be extraordinary to cause a movement of the glacial sheet over say ten degrees of latitude even on level ground, still more "up the slope which the depressed lands thus offered to the ice." The author rejects this theory, for to give a slope of over one degree from the shores of Hudson's Bay to New York would require a thickness of many miles at the source of the stream. Some other explanation has to be sought, for the iceberg theory is deemed inadmissible. Yet drift material has been carried from the Laurentian hills to Cincinnati, at least 500 miles; and the motion would seem to have been so consistently in one direction that where the ice crossed oblique valleys, there is scarcely any deflection of the striæ. The author puts forward another theory, according to which the ice-sheet as a whole is not supposed to have moved constantly southward. The ice came on gradually, its limit extending more southward year by year till the culmination was reached. Only the immediate front might move, most of the ice added yearly would go to increase the thickness, and proportionally so the further north. Then the removal of the excess of ice would take place by "pressure-melting." For a fuller exposition of the author's views on this point, see pp. 146–7, 158–161. We here indicate only the outline of the argument. Each atmosphere of pressure lowers the melting-point of ice by ·0025 of a degree Fahr. Therefore if the ice was near the freezing-point, as it probably would be under a thick sheet, from a certain amount of heat derived from friction, and from the interior of the earth, the weight of a mile of ice would bring about pressure melting at the bottom of the glacier, and the parts most deeply buried would from time to time be crushed into water. This water, since its liquidity was due to pressure, would be only free to move until it obtained a point where the pressure would be sufficiently diminished to permit its return to the solid state. There would scarcely be any crevices in ice of this thickness, the result would be that it would have to move horizontally along the junction of ice and rock, if it moved at all. On this view the ice did not move from the far north southward as ice, but was driven out in the form of water made liquid by pressure and friction. The erosive power of this water carrying along stones and urged by the pressure of the ice is considered as necessarily great. Besides other failings, this theory seems to us to ascribe too much of the characteristic glacial erosion to what is practically the movement of water rather than of ice. It must be added that it is acknowledged by the author as imperfect. A full explanation of this great continental ice-sheet, if it existed, has yet to be given. It is pointed out that its analogue must be sought in Greenland, but of the movements of the ice-fields there little is known.

We have passed over the discussion on the causes of the movement of the Swiss glaciers, which we set down in tabular form with objections and criticisms in a way that will be of great aid to students. Similarly of the causes which have acted in bringing about glacial periods. Dr. Croll's views are accepted in the main, that the last glacial period was probably about 240,000 years ago—a time of great eccentricity, while according to this theory it ought to contain mild interglacial periods in either hemisphere alternately. We would direct readers to the chapter on the relation of glaciation to Man, as one full of interest. The discovery of the Calaveras skull in California, in gravel beneath lava currents, both of which are older than the existing drainage channels, is quoted from Prof. Whitney's original description. It is clear then that here Man was Pre-Glacial if not Pliocene. Hence, as, according to Croll's hypothesis, the last glacial period began about 240,000 years ago, and commenced to pass away about 80,000 years ago, while the Pliocene preceded the former in time, it follows that Man in California must have had that exceeding antiquity. Our author seems not to shrink from this conclusion.

In the chapter on Ancient Glacial Periods will be found a further extension of the argument from striated boulders than we are accustomed to. It would seem that any great thickness of conglomerate is taken as *prima facie* proof of the existence of glaciers, even though striæ may not have been seen on the boulders. There are said to be not less than a dozen periods where we have more or less evidences of ice-action. We read, *e.g.* not only of Miocene and Permian glaciers, but of Eocene, Triassic, Carboniferous, and Cambrian. The Carboniferous conglomerate series contain intercalated beds of coal, a proof that the period was not one of general cold.

The chapter on certain effects of glaciers, and their relation to soils, etc., is suggestive. The soil of drift districts is contrasted with those formed by degradation of rock *in situ*, the latter being less thick is more rapidly exhausted by farming operations. From the grey or blue colour of glacial mud, as compared with river detritus, a hint is thrown out that many of the clays forming the lifeless blue shales of former periods may have come from glacial streams.

Many other points in the volume we have to leave unnoticed. It will be seen, however, that though designed for the use of students, and containing, in condensed form, just the information they require, it is far more than a mere text-book. It abounds with original suggestions resulting from a wide survey of facts. A bibliography is also a useful feature. The volume is the first of a series; we are promised companion volumes on Mountains, Volcanos and Earthquakes, Lakes and Plains, Rivers and Valleys, the Sea and its Shores, Structure of Rocks, and Effects of Life. As Director of the Kentucky Survey, the author has had much opportunity of studying a wide and varied country, while from the treatment of the subject of glaciers we may look forward to many pungent views and always a suggestive line of thought. We hope that author and publisher may be able to bring out the series with as little delay as possible. Continued on the same plan, they will certainly form a mass of gorgeous illustration of geological phenomena in a very accessible shape.

We should add that the senior author is responsible for the letterpress, while Mr. Davis has selected and written the explanation of the Plates. T.

# REPORTS AND PROCEEDINGS.

## GEOLOGICAL SOCIETY OF LONDON.

I.—November 16, 1881.—R. Etheridge, Esq., F.R.S., President, in the Chair.

Prof. Hughes made a brief statement in reference to the Bologna Congress, which will be found more fully expressed in the December, 1881, Number of the GEOLOGICAL MAGAZINE by Mr. Wm. Topley, F.G.S., Secretary to the British Section of the Congress.

Dr. T. Sterry Hunt gave some account of the pre-Cambrian or Eozoic rocks of Europe as compared with those of North America. He had on several occasions studied them, both on the continent and in the British Isles, especially with Dr. Hicks in Wales in 1878. In North America the recognized base is a highly granitoid gneiss, without observed limestones, which he has called the Ottawa gneiss, overlain, probably unconformably, by the Grenville series of Logan, consisting chiefly of granitoid gneisses, with crystalline limestones and quartzites. These two divisions made up the Laurentian of Canada, and correspond respectively to the Lewisian and the Dimetian of Hicks. Resting in discordance on the Laurentian, we find areas of the Norian or Labrador series (Upper Laurentian of Logan), chiefly made up of anortholite rocks, granitoid or gneissoid in texture, with some true gneisses. The Huronian is seen to rest unconformably on the Laurentian, fragments of which abound in the Huronian conglomerates. To the lower portion of the Huronian the speaker had formerly referred a great series of petrosilex or hälleflinta rocks, described as inchoate gneisses, passing into petrosilex-porphyries, occasionally interstratified with quartzites. This series, in many places wanting both in Europe and America, he is now satisfied forms an underlying unconformable group—the Arvonian of Hicks. Above the Huronian is the great Montalban series, consisting of grey tender gneisses and quartzose-schists, both abounding in muscovite, occasionally with hornblendic rocks. The Pebidian of Hicks includes both the Huronian and the Montalban, to which latter belong, according to the speaker, certain gneisses and mica-schists both in Scotland and in Ireland, as he had many years since pointed out. In some parts of North America he found the Montalban resting unconformably on Laurentian. Above the Montalban comes the Taconian (Lower Taconic of Emmons), a series of quartzites and soft micaceous schists, with dolomites and marbles. All these various series are older than the Lower Cambrian (Menevian) strata of North America; and it may be added that the Keweenian or great copper-bearing series of Lake Superior there occupies a position between the Montalban and the Cambrian.

In the Alps the speaker recognizes the Laurentian, Huronian, and Montalban, all of which he has lately seen in the Biellese, at the foot of Mount Viso, in Piedmont. The Huronian is the great *pietre verdi* group of the Italians, and much of what has been called altered Trias in this region is, in his opinion, probably Taconian. The Montalban forms the southern slope of Mont St. Gothard, and is the muscovite gneiss and mica-schist of the Saxon Erzgebirge. Here Dr. Credner and his assistants of the Geological Survey have described abundant conglomerates holding pebbles of Laurentian rocks imbedded in the Upper or Montalban gneiss. The pre-Cambrian age of this has been shown by Credner, who has proved by careful survey that the so-called younger or Palæozoic gneisses of Naumann are really but a continuous part of the older series. Late surveys also show that the crystalline rocks of the Taunus are really Eozoic, and not, as formerly maintained, Devonian in age.

The speaker insisted upon the fact that where newer strata are in unconformable contact with older ones, the effect of lateral movements of compression, involving the two series, is generally to cause the newer and more yielding strata to dip towards and even beneath the edges of the older rock, a result due to folds, often with inversion, sometimes passing into faults. This phenomenon throws much light on the supposed recency of many crystalline schists.

The following communications were read:—

1. "Additional Evidence on the Land Plants from the Pen-y-glog Slate-quarry, near Corwen." By Henry Hicks, Esq., M.D., F.G.S.

The author stated that since the date of his former paper (Quart.

Journ. Geol. Soc., August, 1881) he had ascertained that plant-remains occurred in the slaty beds down to the base of the quarry, though much obscured by cleavage. The larger specimens are in the form of anthracite. Mr. Carruthers states that there is sufficient evidence to show that they are the remains of vascular plants, with some resemblance to the Lycopodiaceæ. Some of the fragments are from 4 to 5 inches wide, and the author had traced trunks some feet in length. He thought they had drifted to the position where they were now found. Leaf-markings generally are not preserved; but from the wrinklings still remaining on some specimens, he thought it probable they had been covered with leaves spirally arranged. Some fragments show scars arranged irregularly on the surface; probably these are fragments of roots. The plant seems to some extent to combine the characters of *Stigmaria*, *Sigillaria*, and *Lepidodendron*. Further details of the appearance of the specimens were given. For one which appears to differ from all hitherto described he proposes the name of *Berwynia Carruthersii*.

2. "Notes on *Prototaxites* and *Pachytheca* from the Denbighshire Grits of Corwen, North Wales." By Principal Dawson, LL.D., F.R.S., F.G.S.

The author stated that he had obtained specimens of the Plant-remains from near Corwen, and that among them there were two kinds, one dark, the other light-coloured. In the former, the long cells and woody fibres are filled with rods of transparent siliceous matter, and the walls represented by a thick layer of carbon. The lighter kind consists of the siliceous rods alone, which are thus in the same state as the asbestos-like silicified Coniferous wood of the Californian gold-gravels. In both the siliceous rods show traces of the irregularly spiral ligneous lining of the cell walls. From these and other characters the author refers the specimens to his genus *Prototaxites*, which, he says, is not an Alga, but a woody terrestrial plant. The author did not state that *Prototaxites* actually belonged to the Taxineæ, but that its fossilized wood showed a resemblance to that of some fossil Taxineæ. The remains discovered by Dr. Hicks differ, as already recognized by Mr. Etheridge, from *Prototaxites Logani*, Daws.; and the species may be named *P. Hicksii*.

Of *Pachytheca* the author stated that he had specimens from the Upper Silurian of New Brunswick, and these and the Welsh specimens seem to belong to the genus *Ætheotesta*, Brongn., and to be nearly allied to *Æ. devonica*, Daws., from the Devonian of Scotland. These fossils occur associated with *Prototaxites*, not only at Corwen, but in the Upper Ludlow of England, in the Upper Silurian of Cape Bon Ami, and in the Lower Devonian of Bordeaux quarry opposite Campbellton in New Brunswick, and as the author maintains *Ætheotesta* to be a seed, and Brongniart compared it with the seeds of the Taxineæ, this may be taken as an additional evidence in favour of the Taxine, or at any rate Gymnospermatous nature of *Prototaxites*.

Prof. Judd stated that he exhibited, on behalf of Mr. Thiselton Dyer, two sections of *Pachytheca*. Mr. Thiselton Dyer regretted that he was unable to be present at the Meeting, but had sent Prof. Judd a letter, from which he read the following extract:—

"I have to thank you for drawing my attention to the paper and discussion in the August number of the Quarterly Journal. Having read this, I venture to think that the specimens which I am placing in your hands may be found of some importance if exhibited at the meeting.

"Their history is briefly this. Some time ago Sir Joseph Hooker received from Mr. Grindrod a number of specimens of *Pachytheca in situ* on pieces of rock. As these examples of the fossils were apparently well preserved, two or three were detached and intrusted to Mr. Norman, who made the sections which are now in your hands. Sir Joseph Hooker did not see his way to any definite conclusion as regards the structure which they exhibited. He, however, allowed me to examine them, and they have since remained in my possession. The conclusion which I arrived at was that their structure agreed, in general plan, with that of *Codium*, as shown in Kutzing, 'Phycologia Generalis,' pl. 42, f. 1.

"As a possible algal nature has been suggested for *Pachytheca* by Mr. Etheridge, I think it may not be considered presumptuous on my part to now state that I have been of opinion, ever since I studied the sections, that *Prototaxites* and *Pachytheca* are both referable to the same morphological type of structure. The radiating cells in the latter terminate internally in loosely interlacing slender filaments, with which the central cavity has been apparently filled. *Pachytheca* does not resemble any type of sporangium with which I am acquainted; the structure, as displayed in the specimens, has a certain resemblance to that of the sporocarp of *Pilularia*; but I cannot reconcile what I have seen of it with the supposition that it was a reproductive structure belonging to any type of vascular cryptogam.

"According to the views which I take of *Pachytheca*, it was an algal organism, closely resembling in essential structure a diminutive *Codium*, but with the peripheral cells branched instead of simple. I do not see any evidence to lead me to suppose that it was related to *Prototaxites* as a sporangial organ. The existence of *Prototaxites* on modern biological views necessarily implies the existence, at some time or other, of allied forms; and I do not see why *Pachytheca* should not have been a contemporaneous one. Kew, Nov. 15th, 1881."

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II.—December 7, 1881.—R. Etheridge, Esq., F.R.S., President, in the Chair.

Mr. W. Topley made a statement respecting the International Geological Congress at Bologna, which has already appeared in the Geological Magazine for December, 1881, pp. 557–561.

Prof. Judd, at the request of Professor John Milne, of the Imperial Engineering College of Tokio, Japan, called the attention of the members of the Society to the important work now being carried on by the Seismological Society of Japan. The objects at which this Society chiefly aimed at were (1) the preparation from ancient Japanese records of a reliable Earthquake-Catalogue; (2) the testing of various instruments devised for seismographical inquiries; (3) the careful observation, at as many points as possible, of the elements of the earthquake-movements; (4) the measurement of the amount of elevation and depression of areas during earthquake-shocks. Already, by the labours of this Society, seismographs had been supplied to many of the telegraphic stations in Japan, and valuable results had been obtained. The Seismological Society of Japan was founded before that of Switzerland. Geologists could become members of the Seismological Society of Japan (which stands greatly in need of help) by an annual payment of £1, which will entitle them to receive the whole of the publications of the Society. Prof. Judd was prepared to receive the names of members on behalf of Prof. Milne.

The following communications were read:—

1. "The Zones of the Blackdown Beds and their Correlation with those at Haldon, with a List of the Fossils." By the Rev. W. Downes, B.A., F.G.S.

The author, after some remarks on the inexact way in which fossils had been collected from or referred to the Blackdown beds, and a sketch of the literature of the subject, passed on to a correlation of the Blackdown beds with deposits in other localities. He pointed out that they do not contain a sufficient number of species in common with the Marne de Bracquegnies to justify an identification with this. He compared them with the Haldon beds, and by a comparison of the fossils bed by bed, showed that of 196 Blackdown species (omitting a few corals), 50 occur at Haldon; the latter section, however, represents not the whole, but only the upper part of the former, nine beds in the lower part of it being without representatives at Haldon. Here also the higher beds contain a thin band distinguished by a distinct and all but unique fauna (the zone containing the corals described by Prof. Duncan). Comparing the Blackdown beds with lists of Cretaceous fossils from other localities, it would appear that we have neither exclusively Upper-Greensand forms at the top, nor exclusively Lower-Greensand forms at the bottom, nor exclusively Gault forms in the middle.

2. "On some new or little-known Jurassic Crinoids." By P. Herbert Carpenter, Esq., M.A. Communicated by Prof. P. Martin Duncan, M.B. Lond., F.R.S., F.G.S.

The author first described in detail a species from the Great Oolite, principally of Lansdown, and hence known as the "Lansdown Encrinite." It was described in 1828 by Dr. J. E. Gray as *Encrinites* (*Apiocrinites*) *Prattii*, and subsequently by Goldfuss as *Apiocrinites obconicus*, and by D'Orbingy as *Millericrinus obconicus*, whilst Bronn, in 1848, recorded it as *Millericrinus Pratti.* The stem varies greatly in length and in the number of its joints; and from the characters presented by the fossils, the author came to the conclusion that the species was either pedunculate or free, and he cited various examples of nearly allied pedunculate and free Crinoids.

The general aspect of the calyx, the component plates of which were described in detail, is exceedingly pentacrinoid, whether it is viewed from the side or from above; and the arm-joints are short and nearly oblong in outline, having pinnules alternately upon opposite sides. The nearest allies of *Millericrinus Pratti* are *M. Nodotianus*, d'Orb., and the var. *Buchianus* of *M. Munsterianus*; and of *Pentacrini* the one which most resembles it in the characters of the calyx is the North-Atlantic *P. Wyville-Thomsoni*.

The remainder of the paper was devoted to the description of two Jurassic Comatulæ, namely, *Antedon colloviensis*, from the Kelloway Rock, described before the Society on June 22, 1881, and a new species, *Antedon latiradia*, from the Great Oolite of Bradford.

3. "Notes on the Polyzoa of the Wenlock Shales, Wenlock Limestone and Shales over the Wenlock Limestone. From material supplied by G. Maw, Esq., F.L.S., F.G.S." By G. R. Vine, Esq. Communicated by Dr. H. C. Sorby, F.R.S., V.P.G.S.

The author has received from Mr. Maw about 1½ hundredweight of materials washed out of the Wenlock deposits of Shropshire, representing the contents of from 6 to 8 tons of unwashed material. From this material he extracted the specimens of Plants, Actinozoa, Echinodermata, Crustacea, and Polyzoa, and he gave a tabular synopsis of the species and their distribution, with the addition of types from the Wenlock Limestone and of the species of Brachiopoda referred to in a paper by Messrs. Maw and Davidson in the GEOLOGICAL MAGAZINE for 1881.

With regard to the Polyzoa, the author remarked that below the Cretaceous series the two great divisions of Cheilostomata and Cyclostomata do not hold good, and suggested that the classification of Palæozoic Polyzoa should be based on the arrangement and character of the cells in combination with habit. The forms characterized in the present paper were:—*Stomatopora dissimilis*, Vine, and vars. *elongata* and *compressa*, *Ascodictyon stellatum*, Nich. & Eth., *A. radiciforme*, sp.n., *A. filiforme*, sp.n.?, *Spiropora regularis*, sp.n., *S. intermedia*, Vine, *Diastopora consimilis*, Lonsd., *Ceriopora*, Goldf., *Hornera crassa*, Lonsd., *H.*? *delicatula*, sp.n., *Polypora*? *problematica*, sp.n., *Fenestella prisca*, Lonsd., *Glauconome disticha*, Goldf., *Ptilodictya lanceolata*, Lonsd., *P. Lonsdalei*, sp.n. ( = *P. lanceolata*, auctt.), *P. scalpellum*, Lonsd., *P. interporosa*, Vine, and *P. minuta*, Vine.

## CORRESPONDENCE.

### THE SUDDEN EXTINCTION OF THE MAMMOTH.

SIR,—In speaking of "the old and, I had hoped, extinct theory of violent changes and the sudden extermination of a species," I intended to have said extinct in *England*; for no one acquainted with continental opinion would venture to call it extinct there, though at last foreign geologists are beginning to abandon such misleading terms as "Diluvium" for the deposits known in this country as Pleistocene. It may be from too exalted a view of the advances recently made in this country that the conclusion has been arrived at, but my impression after reading a number of foreign papers is that for this particular period we are a good deal in advance of most other nations. The wonderful variety of the beds in Britain, their fossiliferous character, and the splendid series of cliff sections and caves in our islands has given us unequalled opportunities for the study; opportunities well used by such careful observers as Lyell, Prestwich, Ramsay, Geikie, and Boyd Dawkins. In most parts of the Continent the Pleistocene deposits appear to be represented by one tolerably uniform mass, like the Loess of the Rhine or the Tundras of Siberia; but in England we have beds showing great alternations of climate, but gradual changes allowing time for the migration of species.

Frozen carcases of Mammoth and Rhinoceros were spoken of as of occasional occurrence, for the greater number that are found are merely skeletons, or portions of skeletons, from which the flesh has long decayed. The extermination of the Mammoth in Britain and Germany may be referable to human agency, while in Siberia it was gradually killed by the increase of cold and want of food—there is as yet no evidence that the extinction in the different districts was simultaneous. A change of temperature of 1° in a century would be extremely rapid from a geological point of view; but Mr. Howorth would bring into play a change of probably 20° in a few .months. At present only two modes are known by which a marked alteration of the climate can be brought about, extensive modification in physical geography and astronomical changes; but both these would be of slow operation, and unless a strong case can be made out, we can scarcely accept a sudden fall of temperature referable to no known cause.

Perhaps Mr. Howorth, as an antiquary, is inclined to pay more attention to authority than a field geologist is likely to do; but the training on the Geological Survey is such as to lead one to believe nothing we are told and only half what we see. Of course, if we accept such authorities as Cuvier, Buckland, and d'Archiac as examples of modern opinion, diluvial theories are still in full vigour. But the systematic study of Pleistocene Geology only commenced about forty years ago, and even now the beds are often treated as abnormal deposits, to which ordinary rules do not apply.

Mr. Howorth scarcely does justice to the views of the followers of Hutton and Lyell, for the uniformitarian theory does not necessarily preclude much more rapid changes than are now taking place. After several years study of Pleistocene Beds, I think that, as a rule, things did then progress faster, and that we are now in a period of exceptionally slow changes. I take uniformitarianism to mean that no cataclysmic explanations must be adopted until it is clearly proved that the phenomena are inexplicable by reference to forces now in operation, and it is only from this point of view that I have ventured to criticize Mr. Howorth's papers.

WITHERNSEA, HULL, CLEMENT REID.
*Dec. 5th*, 1881.

## SUBSIDENCES AT BLACKHEATH.

SIR,—A friend has just sent me the report of the committee for the exploration of the subsidences of Blackheath.[1] The description of the locality by Mr. Holmes is very clear; and the arguments for an archæological explanation of the phenomenon well put. There is one point, however, that is not mentioned. I would ask, are these occurrences a new feature at Blackheath? It appears that *one* occurred in April, 1878, and *two* in November, 1880. It is hardly probable that three should have occurred within so short an interval from causes which, if they be those suggested by Mr. Holmes, must at any rate have been in operation for at least centuries; and no such event have happened before.

I have not examined this locality, but Mr. Holmes' excellent diagram renders that hardly necessary.

I have given some attention to phenomena of this kind. In 1858 I examined, and described in the Journal of the Geol. Soc.,[2] a most remarkable but too little known collection of natural conical pits on Affpuddle and Piddletown Heaths in Dorsetshire. The stratification is there very similar to that at Blackheath, but the depth to the chalk surface probably less. The pits may be counted, I suppose, by hundreds. The larger ones are marked by small circles on the Ordnance Map. It is evident that the sinking of the soil is in constant progress, for there are recent shallow step-like depressions round the edges of many of the pits, and I have been assured by old residents in the neighbourhood, that a well-shaped pit once suddenly appeared, and its sides afterwards fell in. There is, then. evidently a constant cause at work, and its result continually manifested. Is there any evidence of this being the case at Blackheath? Apparently not. The cases, therefore, are probably not analogous; and this would be sufficiently accounted for by the greater depth of the chalk at Blackheath, and the nearness of the water-level in it to its upper surface; so that "pipes" would not be produced in the chalk beneath the Tertiaries.

But I have also described another instance of a natural pit formed quite recently, where, as far as I know, none had ever been formed before; and in other respects having points of similarity to those at Blackheath. This occurred in 1861 at Lexden, near Colchester. It is described in this MAGAZINE.[3] The points of similarity appear to be; (1) The novelty of the occurrence; (2) The depth of the chalk below the surface; (3) The chalk being covered by an impervious stratum (London clay); (4) The surface of the chalk being below the water-level of the district; (5) The recent establishment of works in the neighbourhood, pumping water from the chalk.

By sending these remarks I do not presume to controvert the archæological view taken of the case, for I have no special knowledge to bring to bear on that side of the question. But I have thought it worth while to recall attention to the Lexden subsidence, and to my remarks upon it.

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[1] Blackheath: Edgar Neve; 1881.

[2] Vol. xv. p. 187, 1859. It need hardly be said that the views there given on denudation are out of date.

[3] Vol. II. No. 9, p. 101. (The diagram being inverted is corrected at the end of No. 10, facing p. 192.)

O. Fisher.

Harlton, Cambridge, 11 *Dec.* 1881.

## JUKES AND THE SUPPOSED LAURENTIAN ROCKS IN DONEGAL, IRELAND.

Sir,—From a letter that I have received, it would appear that some question my statement in the letter on the "Lower Palæozoic Rocks of Wexford," that *Jukes first suggested the possibility of there being Laurentian rocks in Donegal.* I find that new men in new countries, who do not take the trouble to learn what others have previously done, often bring forward "new discoveries," which, although new to them, are well known and old to those acquainted with the country. The present question appears to be a case in point. It must be about twenty years ago when Jukes first suggested that some of the rocks in Donegal were possibly of Laurentian age, and when King, of Galway, made a similar statement in reference to the Connemara rocks. At all events, when I was sent to the West Galway district about the year 1863, I was specially instructed on this point, because it was supposed that possibly Laurentian rocks might be found in Galway, Mayo, and Donegal. While working in North-west Connaught from 1863 to 1871, I have over and over again discussed the probability of Laurentian existing in the above-named counties with Jukes, King, Melville, Harkness, and all other geologists who visited me during those years, among whom was Prof. Hull. I suspect that even Sir R. I. Murchison, in the papers published in the Geol. Mag. about that time, also mentions Mr. Jukes' suggestion as to the Laurentian age of some of the Donegal rock, but I cannot here refer to those papers. I therefore believe that I am quite justified in stating as I have done in the first chapter of the "Geology of Ireland," and in my late letter to the Geol. Mag., that any credit due is due to Prof. Jukes, until some one works out the question in detail; which has still to be done. At present even the age of the associated rocks with those suggested to be Laurentians is uncertain. They may be of the same age as those at Creggaunbaun, south of Clew Bay, which have been proved by Syme to be Upper Silurians; or they may be Cambro-Silurians; or in part they may be, as suggested by me in the paper read before the Royal Irish Academy, "On supposed Cambrians in Cos. Tyrone and Mayo," Cambrians; or, as does not appear improbable, if the statements made in reference to the Donegal rocks are correct, all the rocks of the country may belong to one sequence, the supposed Laurentians being a portion that is more metamorphosed than the rest; and as in many other metamorphic regions, brought down by a fault or faults into a juxtaposition with less altered rocks.

The latter suggestion is a very natural one, when we consider that on account of a similar position of rocks, a portion of the rocks of West Galway are said to be of Laurentian age. Now, in West

Galway the geological age of the rocks is quite plain to those who will take the trouble to carefully work them out in detail; some of these rocks are excessively metamorphosed, in places being altered into granite, yet these granites can be traced into gneiss, and from that through schist and the "submetamorphic rocks" into rocks that contain fossils similar, according to Baily, to those characteristic of the Llandeilo rocks. Yet now we are told that the extremely metamorphosed portion of these rocks "are probably of Laurentian age." In one of the papers previously referred to, Sir R. I. Murchison made a somewhat similar statement, but in a subsequent paper he retracted it.

G. H. Kinahan.

Ovoca, *Dec.* 8th, 1881.

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## "MONTALBAN" ROCKS IN SCOTLAND.

Sir,—In the published account of the very interesting and important address delivered before the Geological Society on Nov. 16th, by Dr. Sterry Hunt, "On the Eozoic Rocks of Europe as compared with those of North America," it is stated that the "Pebidian of Hicks includes both the Huronian and the Montalban, to which latter belong, according to the speaker, certain gneisses and mica-schists both in Scotland and Ireland." I have repeatedly expressed the opinion that the great Pebidian formation, as at present defined in this country, will have to be divided into several distinct series, and that it is not improbable that we include in it now formations unconformable to one another. In describing the Scotch rocks (Proc. Geologists' Assoc. vol. vii. p. 20), I called special attention to a series of gneisses and mica-schists along the sides of Loch Eil, and I said that these "differ considerably from those further west, and strike from N.E. to S.W., with an average dip of about 45° to the N.W. They alternate with a corrugated mica-schist and with quartzose bands, which are spotted with a greenish micaceous mineral. These I look upon as newer than the Loch Shiel series, and probably faulted down against the latter. They should probably be classed with the Pebidian rocks of Anglesea, and with others to be further referred to in the more central parts of Scotland." I showed specimens of these rocks to Dr. Hunt, and he immediately recognized their great resemblance to his Montalban series. My chief reason for including these in the Pebidian was that they are undoubtedly newer than the gneisses farther west, and that they had the general strike of the undoubted Pebidian rocks found along the Caledonian Canal. That they will, however, in time have to be separated from the latter is certain, and that they moreover occupy extensive areas in the Grampians, I have proved from careful examination. At Tyndrum, and also in many areas to the north-east and east, they are well exposed. Indeed, they may be said to be the most important series in the Grampians; hence I proposed to Dr. Sterry Hunt that they should in future be separated from the Pebidian under the distinctive name of "Grampian Series."

Hendon, *Dec.* 1881. Henry Hicks.

## COAL UNDER NEW RED SANDSTONE.

SIR,—Allow me to express my regret that I should have overlooked the paper read by Mr. De Rance before the Geological Society of Manchester, in which he gives a detailed section of the Winwick Borehole, one of those which I described in my paper on Coal under New Red Sandstone, and identifies the limestone met with in this borehole as the probable equivalent of the Ardwick Limestone.

I was first made aware of this paper by Mr. De Rance's letter in your last Number.
A. STRAHAN.

CHESTER, *24th November*, 1881.

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## COLOURING OF GEOLOGICAL MAPS.

SIR,—I should be glad if some member of the English Committee for reporting upon the colours, etc., to be employed on geological maps, would kindly explain to me one or two difficulties which the following passage in their report (see pp. 560-61, of this MAGAZINE for December, 1881) has caused me:—"Igneous Rocks.—Four colours would suffice. . . .

| | |
|---|---|
| Basalt and Greenstone | Dark Carmine. |
| Trachyte, Felstone, etc. | Permanent Scarlet. |
| Granite | Vermilion. |
| Modern Volcanic Rock | Light Orange." |

I believe there are three coarse crystalline rocks called syenite, diorite, and gabbro, which can often be recognized by the eye with tolerable certainty. How are they to be coloured? Do any of these alleviate the loneliness of granite, or are the arms of greenstone wide enough to embrace them all? Again, we are told that modern volcanic rocks are to be coloured "light orange." But I thought basalt and trachyte (for which separate colours are provided) were frequent products of modern volcanos? Further, many authors in rough grouping put the leucite-basalts and the nepheline-basalts with the ordinary or felspar-basalt; if so, what *are* the modern volcanic rocks? if not, on what grounds are felspar-basalt and trachyte considered so much more ancient than the others? The olivine rocks and serpentine are, I suppose, omitted on the ground *De minimis non curat lex.*

I should be really thankful to have my perplexities enlightened; for I feel quite hopeless of solving them without external help; and if any member of my class asked me for an explanation I should not know what to say, unless I modified a well-known formula for silencing doubters, and replied: *Bononia locuta est, causa finita est.*
T. G. BONNEY.

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NORWICH GEOLOGICAL SOCIETY.—At the Annual Meeting of this Society, held at the Royal Hotel, Norwich, on November 8, 1881, Mr. W. Whitaker, B.A., F.G.S., was elected President in the room of Mr. J. H. Blake. The retiring President gave an elaborate address on Conservancy of Rivers, Prevention of Floods, Drainage, and Water Supply. Mr. Whitaker, who is engaged on the Geological Survey of the neighbourhood of Lynn, announced at the ensuing meeting, held on December 6, his discovery of Totternhoe Stone near Roydon Church, not far from Grimston Road Station, on the Lynn and Fakenham Railway.

# ABSTRACTS OF THE PROCEEDINGS

OF THE

# GEOLOGICAL SOCIETY OF LONDON.

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No. 413.] [Session 1881–82.

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**January 25, 1882.—R. Etheridge, Esq., F.R.S., President, in the Chair.**

John Blaikie, Esq., Bridge House, Newcastle, Staffordshire; M. Ernest Jobling, Esq., South Tawton, Devon; and the Rev. Stanley A. Pelly, B.A., Thorncliffe, Saltford, near Bristol, were balloted for as Fellows of the Society.

Richard Kerr, Esq., 19 Copt Hall Place, Folkestone; Baron Ferd. von Müller, K.C.M.G., M.D., Ph.D., F.R.S., Director of the Botanic Gardens, Melbourne; William Whitehead Watts, Esq., B.A., Broseley, Shropshire; and Joseph Wilkinson, Esq., F.R.G.S., Coney Street, York, were proposed as Fellows of the Society.

The List of Donations to the Library was read; it included, among others, the following works:—Outline Sketches in the High Alps of Dauphiné, by T. G. Bonney; Palæontologia Indica, ser. 14, Tertiary and Upper Cretaceous Fossils of Western Sind, Vol. 1, pt. 3, The Fossil Echinoidea, fasc 1, by P. M. Duncan and W. P. Sladen; Contributions à la flore fossile du Portugal, par O. Heer; Traité de Géologie, fasc 4, par A. de Lapparent; The Statistical Atlas of England, Scotland, and Ireland, part 12, Geology and Mining, by G. P. Bevan; and Autobiographie du Docteur médecin Ami Boué.

The Secretary announced that the following works, ordered to be purchased by the Council, were also on the table:—Description géologique et paléontologie des Pyrénées de la Haute-Garonne, par A. Leymerie; Ricerche chimiche e microscopiche su Roccie e Minerali d'Italia, per A. Cossa; Excursions Géologiques à travers la France, par S. Meunier; Der Bergsturz von Elm den 11 September 1881, von E. Buss and A. Heim; Untersuchungen über Erzgange, Heft 1, von F. Sandberger; Handbuch der krystallographisch-physikalischen Chemie, Abth. 1, von C. F. Rammelsberg; Elemente der Mineralogie von C. Naumann. Elfte Aufl: von F. Zittel; and Le Sel, par E. Lefebore.

The following communications were read:—

1. "On the Fossil Fish-remains from the Armagh Limestone in the Collection of the Earl of Enniskillen." By James W. Davis, Esq., F.G.S., F.L.S.

The author described in this paper a large collection of fossil fish-remains at present at Florence Court, Enniskillen, but which will soon be removed to the new Natural History Museum in the Cromwell Road. The collection comprises, besides specimens collected by the Earl of Enniskillen from the Carboniferous Limestone of Armagh, a large series acquired from the famous collection of the late Captain Jones, M.P., the remaining portion of which is in the Geological Museum of Cambridge. Several genera and species were described by Prof. Agassiz in his 'Recherches sur les Poissons Fossiles' (1833–43), and again referred to by J. E. Portlock, F.R.S., in his 'Report of the Geology of Londonderry and parts of Tyrone and Fermanagh' (1843).

In 1854 Prof. M'Coy described many new genera and species in his work on the 'British Palæozoic Rocks and Fossils,' principally derived from a study of the portion of Capt. Jones's collection deposited in the Cambridge Museum. Prof. Agassiz paid a visit to Florence Court in 1858, and appended names to some of the fossil teeth in Lord Enniskillen's cabinets, intending to describe and figure the new forms, and to revise the whole of his former work. His death prevented this intention from being carried into effect. As far as possible the determinations of Prof. Agassiz have been adhered to in the present paper.

The detached and isolated condition in which the remains are found renders any appreciation of the relationship of the teeth and spines, or even of the teeth only, to each other extremely uncertain and difficult. Some speculations as to the probable organization and characteristics of the Carboniferous fishes which they represent, evolved during a long consideration of the specimens, have therefore been postponed to a future opportunity.

The following is a list of the genera and species described in the paper:—

*Ctenacanthus plicatilis*, *C. dubius*, *C. lævis*, *C. pustulatus*, *C. tuberculatus*, *Compsacanthus carinatus*, *Cosmacanthus marginatus*, *C. carinatus*, *Lispacanthus retrogradus*, *Cladacanthus paradoxus*, *C. major*, *Gnathacanthus triangularis*, *Cladodus polyodon*, *C. curvus*, *C. destructor*, *Carcharopsis Colei*, *Copodus cornutus*, *C. furcatus*, *C. spatulatus*, *C. minimus*, *Labodus prototypus*, *L. planus*, *Mesogomphus lingua*, *Pleuragomphus auriculatus*, *Rhymodus transversus*, *R. oblongus*, *Characodus angulatus*, *C. luneatus*, *Pinacodus gonoplax*, *P. gelasi*, *Dimyleus Woodi*, *Mylax batoides*, *Mylacodus quadratus*, *M. Sesarma*, *Homalodus trapeziformis*, *H. quadratus*, *Petalodus quadratus*, *P. recurvus*, *P. inequilateralis*, *Polyrhizodus magnus*, *P. Colei*, *P. elongatus*, *P. sinuosus*, *P. attenuatus*, *P. constrictus*, *Chomatodus linearis*, *C. acutus*, *Glossodus marginatus*, *Harpacodus dentatus*, *H. clavatus*, *Streblodus oblongus*, *S. Colei*, *S. Egertoni*, *Deltodus sublævis*, *D. expansus*, *D. nobilis*, *Deltoptychius acutus*, *D. gibberulus*, *Sandalodus Morrisii*, *Psephodus magnus*, *Pœcilodus Jonesii*, *P. gibbosus*, *Tomodus convexus*, *Xystrodus striatus*, *X. angustus*, *X. Egertoni*, *Helodus crassus*, *H. tenuis*, *H. clavatus*, *H. dilatatus*, *H. acutus*, *H. richmondensis*, *H. triangularis*, *H. biconus*, *H. expansus*, *Rhamphodus dispar*, *Petalorhynchus psittacinus*, *Pristodus falcatus*.

### DISCUSSION.

Prof. SEELEY suggested that in the fang-like portions of the teeth in *Polyrhizodus* we have indications of an analogy with the Rays, and that the teeth may have followed each other in series. He thought that many forms relegated to different genera and species might belong to the same palate. He spoke of a similar variety of form being exhibited in the teeth referred to *Cochliodus*. He referred to the difficulty of dealing with the remains which had been thought to be allied to the *Diodon*.

The PRESIDENT testified to the great labour undertaken by Mr. Davis in investigating the large collection of fossils brought together by the Earl of Enniskillen. Apart from the determination of the analogies of these forms, the naming and description of these characteristic fossils would be of great service to stratigraphical geologists.

The AUTHOR admitted that some of the forms described might belong to the same palate; but until actual evidence of this was produced, he maintained that they ought to be described and receive distinctive names. Many of the names had been attached to these fossils by Agassiz. He mentioned the discovery of Worthen that the teeth referred to the genera *Cochliodus* and *Helodus* occur associated in the same jaw in an American specimen. He thought many of the teeth were not palatal teeth but were inserted in, or on the ramus of each jaw.

2. "On an extinct Chelonian Reptile (*Notochelys costata*, Owen) from Australia." By Prof. Owen, C.B., F.R.S., F.G.S.

The fossil reptilian remains hitherto transmitted to the author from Australia have been limited to parts of the skeleton of *Megalania prisca*, Ow. The present specimen, sent last year by Prof. Leversidge, is the first fossil Chelonian. The specimen was found in a formation at Blinder's River, Queensland, of which the nature and age are not stated. It is, however, petrified. The fossil consists of the anterior portion of the carapace and of the plastron, brought into unnaturally close contact by posthumous pressure. A minute description of the several parts was given, from which the author concluded that though the characters of the carapace might be interpreted as identifying the Chelonian with a true turtle (*Chelone*), those of the plastron show the well-marked distinctions of *Trionyx* and *Chelys*. On the whole, however, the modifications, especially of the carapace, show a nearer affinity to the marine turtles (*Chelone*) than the known Chelydrians exhibit, and indicate a more generalized type.

### Discussion.

Prof. **Seeley** regretted that the specimen upon which the pa was founded was not upon the table. It would also have be helpful if the author had attempted a restoration. He pointed how much the elements of the plastron must have been displac He could not help suggesting that the hyo-hyposternal bones w not combined, but that those preserved were the hyosternal bo only. If this were possible he doubted the propriety of the na *Notochelys*, as if the above point were not proved, there was nothi to separate the genus from *Chelone*. Had the peculiar modifi tion of the plastron supposed by the author existed, he shou have expected more marked differences in the carapace. At t same time the value of the contribution could not be doubted.

### 3. "On the Upper Beds of the Fifeshire Coal-Measures." By t late E. W. Binney, Esq., F.R.S., F.G.S., and James W. Kirkby, Es

These beds are best exposed in Fife, between the mouth of t Leven and East Wemyss. The coalfield of the latter district is t most northerly piece of true Coal-measures in Britain; they d 10° E., or even less. The highest member (which may possib be even later than the Carboniferous Period) is an unfossilifero purplish sandstone, full 200 feet thick; next comes soft red ma 12 feet, followed by sands, 290 feet, marls, clays, &c., 100 feet, a sandstones, clays, &c., with thin coals and limestones, about 80 fee Other sections were also described. No unconformity has be noticed in Fifeshire between these and the underlying measure The argillaceous limestones and their coals are fossiliferous; the are a few fish and crustacea, and many plants, with some curio markings, which may be rootlets or perhaps algæ. The last occ only in a limited part of the rock, not with other plants, and a very delicate and membranous. The affinities of these were full discussed, the author inclining to the view that they are algæ.

### Discussion.

The **President** spoke of the value of the physical and palæonto logical informotion conveyed in this paper.

Mr. **Tiddeman** spoke of a section he had found along the Gret near Ingleton, where some thin limestones occur at a considerabl height above the true Coal-measures: over the latter were plant bearing sandstones, shales, and clays, and apparently correspondin with them, on the other side of a synclinal, were beds of simila rocks, but with limestone interbedded. These were almost dolomiti No organic remains had been found in them. It was, however, jus possible that these limestones, being near the Great Craven Fault might not be Upper Coal-measures but Yoredale-Grit beds; but o the whole the probability lay the other way.

Mr. **Cruttwell** inquired the thickness of the limestone. I Australia there were limestones with *Productus reticulatus* under th productive Coal-measures.

Dr. Murie said he thought that rootlets of *Lepidodendron* had been found *in situ* in the north. He thought these beds could be traced westward to the other coal of Scotland.

The President remarked that it was singular how closely some of the Australian fossils corresponded with those of Britain.

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Specimens were exhibited by Messrs. Davis and Kirkby in illustration of their papers.

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The next Meeting of the Society will be held on Wednesday, February 8th, 1882, when the following communications will be read:—

1. "Descriptions of some Iguanodon Remains, indicating a new species, *I. Seeleyii.*" By J. W. Hulke, Esq., F.R.S., F.G.S.

1. "On a peculiar Bed of Angular Drift on the high Lower-Chalk Plain between Didcot and Chilton." By Prof. Joseph Prestwich, F.R.S., F.G.S.

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Ridley Henderson, Esq., 9 Bush Lane, E.C.; William John, Esq., M.R.C.S., Court House, Haverfordwest; and James Robert Millar Robertson, Esq., M.D., Clydeside House, Renfrew, Renfrewshire, Scotland, will be balloted for as Fellows, and Prof. S. Lovén, of Stockholm, as a Foreign Member of the Society.

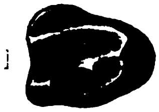


Fig. 2.

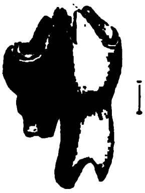


Fig. 1a.

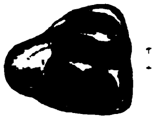


Fig 1

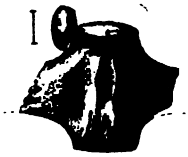


Fig. 9.

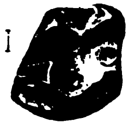


Fig. 3.

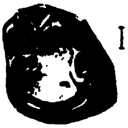


Fig. 4.

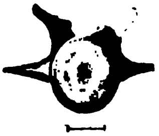


Fig. 9a.

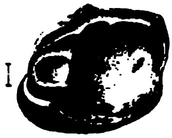


Fig. 5.

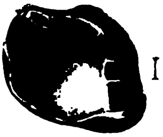


Fig. 6

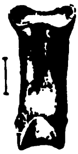


Fig. 11.

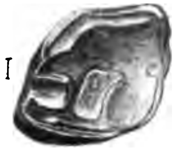


Fig. 7

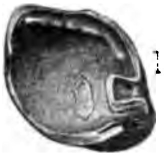


Fig. 8.

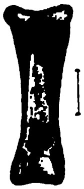


Fig. 10

Fig 12.

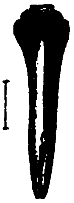


Fig. 13

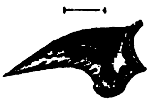
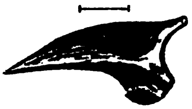


Fig. 12a



T. Newton del. et lith. West Newman & Co.

*Spermophilus* from beneath the Glacial Till of Norfolk.

THE

# GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. IX.

No. II.—FEBRUARY, 1882.

## ORIGINAL ARTICLES.

### I.—On the Occurrence of the *Cyrena fluminalis* at Summertown, near Oxford.

By Professor J. Prestwich, M.A., F.R.S., F.G.S.

A CONSIDERABLE length of section of the river valley-gravel has recently been laid open in the grounds of St. Edward's School, Summertown It is only 200 or 300 yards distant from the Summertown brick-pit, where the same gravel is exposed, and which is there close on the edge of the Thames valley; nevertheless, this section presents features which have not been observed there or at any other place, numerous as are the sections of the superficial gravel and sand in the neighbourhood of Oxford.

Section exposed in digging the foundations for new buildings, St. Edward's School, Summertown, Oxford:—

| | ft. | in. |
|---|---|---|
| 1.—Soil with a few fragments of the underlying gravel .................. | 1 | 0 |
| 2.—Light-coloured, fine gravel (with irregular black and ferruginous veins) composed of water-worn fragments of the Great and Inferior Oolites, Forest Marble and Cornbrash, with specimens of the *Gryphea dilatata* from the Oxford Clay, and of older rock pebbles (quartzites, etc.) and Chalk flints from the Glacial Drift.............................. | 3 | 2 |
| 3.—Fine yellow sand with *land and freshwater shells*, and fossil remains of *Elephant, etc.*, in the lower part .......................... | 3 | 6 |

Under this by digging I found three feet more of sand, and then some hard gravel, which rests probably on the Oxford Clay.

In the Oxford district, this gravel occupies a level or terrace about 20 to 25 feet above the level of the Thames and Cherwell, and small patches of the same gravel are met with *on the same level* at the foot of the hills on the other side of the valley at Wytham and North Hincksey, having once extended across the valley at that level, and the valley below that level having since been excavated by prolonged river-action to its present depth. After that the valley received the alluvial deposits which now form the flat river lands such as Port Meadows, and which contain the remains of the Red Deer, Roebuck, Wolf, Wild Boar, Horse, Ox, etc.

The gravel consists of water-worn fragments of various Oolitic rocks belonging to strata over which the Thames and its tributaries flow above Yarnton and Eynsham, that is to say, strata which form the hills about Handborough and Charlbury, and the slopes of the Cotswold Hills beyond Witney, together however with the harder shells washed out of the Oxford Clay, such as the large *Gryphe dilatata*, and *Belemnites*. There are also large rounded pebbles o quartzite and other Palæozoic rocks, but these come from an olde glacial drift gravel found on the summit of Wytham, Bladon an other high hills, still in the same watershed. Sometimes the grave is roughly piled together, at other times it is rudely bedded, whil occasionally the sands present the fine lamination due to more tranquil deposition arising either from diminished force of the curren or from being in more sheltered places.

In the gravel-pits at Summertown and elsewhere around Oxfor it is rare to find even fragments of shells, and only still more rarel are a few perfect shells met with. But at the St. Edward's sectio where the beds are finer and consist chiefly of sand, owing probabl to their having been deposited more out of the way of the mai current, the shells are in places numerous, and almost all are entir —some indeed are double, though they are very fragile.

They consisted chiefly of *Pisidium*, *Limnea* and *Cyrena*. Wit one exception there was no record of the existence in this area o indeed in any part of the Upper Thames Valley, of the *Cyren fluminalis*. That exception is a *single* specimen found some yea ago by Mr. Tiddeman, of the Geological Survey, in a small pit o section on the banks of the Cherwell, but I have never succeede in finding this pit or section, which has no doubt been filled up o sloped over. So the evidence of the occurrence in this district o this particular fossil rested on that single specimen, which is preserve in the Oxford Museum. In the St. Edward's section this shell ha again been discovered in considerable numbers—of all sizes, an double, proving that it lived and flourished here at the period i question. It is in fact the most abundant shell there.

The following is a list of the various shells I have obtained fro the St. Edward's section:—

UNIVALVES.
*Ancylus fluviatilis.*
*Bithynia tentaculata.*
*Limnea peregra.*
,, *truncatula.*
*Planorbis ?*
*Valvata piscinalis.*

BIVALVES.
*Cyrena fluminalis.*
*Cyclas ?*
*Pisidium amnicum.*
*Unio* (fragments only.)

LAND SHELLS.
*Helix hispida.*
,, *pulchella.*

Together with these shells there were found some fossil bone mostly of large size, and a few teeth. Unfortunately, the bones ar so much decomposed and so soft, that it has not been possible t preserve the specimens. One of these was the entire *humerus* of a Elephant, but the others were indeterminable. The teeth are thos of *Elephas primigenius*, one specimen is almost perfect and but littl worn, whereas the other is worn down to a mere stump. Simila remains of the Mammoth are extremely abundant in the grave under Oxford; the lower jaws of five or six individuals having bee found in digging the foundations of the New Schools, and nearly a many more in making the Drainage works at Holywell.

In the adjacent Summertown brick-pit, the same gravel contains greater variety of and better preserved Mammalian remains, consisting of the following species:—

| | |
|---|---|
| *Elephas primigenius.* | *Equus fossilis.* |
| *Rhinoceros tichorhinus.* | *Bos primigenius.* |
| *Cervus elaphus.* | *Sus scrofa.* |
| „ *capreolus.* | |

The Hippopotamus has been found at Wytham on the opposite side of the Thames, and the Reindeer at other places in the Oxford district, but their remains are extremely scarce.

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## II.—ON THE OCCURRENCE OF *SPERMOPHILUS* BENEATH THE GLACIAL TILL OF NORFOLK.

By E. T. NEWTON, F.G.S.;
of the Museum of Practical Geology, Jermyn Street.

(PLATE II.)

THE remains of the genus *Spermophilus* have been so rarely found in Britain that an account of another example could not but be of interest to geologists; but the specimen described below is especially noteworthy as it has been obtained from a deposit only recently discovered, and from which no vertebrate remains have as yet been recorded. The deposit referred to is the "Arctic Freshwater Bed," discovered near Mundesley, by Mr. Alfred Nathorst (*vide* Journ. of Botany, vol. iii. 1873, p. 225), and investigated by my colleague, Mr. Clement Reid, during the survey of the Norfolk coast (GEOL. MAG. for Dec. 1880). This deposit is believed to be the first definite indication of the arctic climate, which gradually increasing reached its climax in the Glacial period; it immediately underlies the Till, and is regarded by Mr. Reid as the earliest bed of the Glacial or Pleistocene epoch; it has yielded to my colleague's careful and laborious investigation a large number of arctic plants, and it was while searching for these that he came upon some fragments of bone, lying only a few inches below the superincumbent 40 feet of glacial deposits. Although these fragments were very unpromising, yet, as they were the first that had been met with in the bed, he carefully removed and washed as much of the surrounding matrix as seemed likely to contain any part of the specimen. By this means a number of pieces of bone were obtained, most of which were so small and broken as to be indeterminable, but among them were eight grinding teeth, which undoubtedly belong to the genus *Spermophilus*, and some bones of the feet which had not been injured.

The only instances recorded of the occurrence of the *Spermophilus* in this country are those mentioned by Dr. Falconer (Pal. Memoirs, vol. ii. p. 452), and by Prof. W. Boyd Dawkins (Mon. Pal. Soc., 1864, p. 37). The two specimens described by Dr. Falconer as *Spermophilus erythrogenoides* were from the Mendip caves, and the third, which was figured but not named, was from the "Pleistocene clay at Fisherton, Salisbury." Prof. W. Boyd Dawkins alludes to another specimen in the Taunton Museum as being most closely allied to the *Sp. citillus,* and mentions several examples of the genus

from the Fisherton gravels "which have yet to be determi
The specific determination of these *Spermophili* seems to have r
almost wholly on the form of the mandibular rami; but as the
folk specimen has only the teeth of the lower jaw preserved,
mode of determination cannot be adopted. Detailed measurem
of the lower jaw and teeth of *S. erythrogenoides* were made b
Falconer; but only those of the teeth can be made use of i
present instance; they are thus given in vol. ii. page 452: "Le
of three posterior molars 0·4 in." [= 10·2 mm.] "Length of
occupied by the four molars 0·52 in." [= 13·4 mm.]

Of the eight teeth obtained from the "Arctic Freshwater I
six belong to the lower jaw and appear to be the first, second
third cheek-teeth of the right and left sides. The other two
are from the upper jaw. The lower teeth are all so much worn
the dentine is exposed over nearly the whole surface, having o
small depression of enamel on the outer side. The enamel bo
which in the recent forms stands up as a ridge, is in these
broken, or worn away. The forms and proportionate sizes wi
best understood from the figures (Plate II. Figs. 3 to 8). Th
terior pair, which are believed to be the fourth premolars, have
lost their fangs, and the broken surface does not show how
each had. The other four lower teeth, which seem to be the firs
second true molars of the right and left rami, have each four fa

The space occupied by the three lower teeth on each side is ·
(= 8·5 mm.), and the four when altogether probably measure
nearly as possible, ·45 in. (= 11·5 mm.).

The two upper teeth are less worn, and retain their characte
cusps and ridges, the black surface being to a great extent co
by a whitish layer of what appears to be much worn enamel; b
this I cannot be certain. The crown of each tooth is irregu
triangular in outline (Figs. 1, 2), and has one large inner cusp
three smaller outer ones. A prominent ridge, or rather two ri
in the form of a horse-shoe, connect the outer and two anterior
cusps, and thus inclose a deep transverse valley, which is clos
the inner side by the one large cusp, but opens outwards bet
the two smaller ones. The hindermost ridge has another cusp
midway between the inner and outer cusps. In front of the *h*
*shoe* ridge there is a secondary valley inclosed by a slight r
which forms the anterior boundary of the crown, but this is
much lower level than the *horse-shoe* ridge. At the hinder p
the tooth a slight ridge runs down from the large cusp, and cu
round joins the hinder outer cusps so as to inclose a slightly depr
space. A small guard is to be traced around the hinder marg
the crown. The antero-posterior extent is about ·1 in. (2 5
The difference in size in the figures is chiefly due to the some
different direction in which they were viewed in drawing them.

I have compared these teeth with those of the recent Eur
species in the Brit. Mus. and Royal Coll. of Surgeons. In all
recent forms the lower cheek-teeth are much alike, and alth
there appears to be some difference in the proportionate sizes o

anterior cheek-teeth, yet these are not sufficiently marked to enable one to separate the species. On the whole these fossil teeth would seem to agree best with those of *S. citillus* and *S. Altaicus* (= *S. Eversmannii*). And judging from the measurements of the teeth of these two species given by Dr. Nehring (Neuen Jahrbuch, 1880, Band II. p. 121), and of those in the British Museum, our fossils agree best with the *S. Altaicus*; for the three teeth preserved are as long as the four in *S. citillus*, that is, 8·5 mm., while the length occupied by the four when complete must have been as nearly as possible the same as in the *S. Altaicus*, that is, 11·5 mm. It will be noticed that these measurements are much less than those given by Dr. Falconer for his *S. erythrogenoides*, which was 0·52 in. or 13·4 mm.

Dr. Nehring sems to think (*loc. cit.*) that Dr. Falconer's species is very closely allied to the *S. Altaicus*, if not the same; but the measurements are certainly much greater than in the latter species.

With regard to the upper teeth, the recent *S. Altaicus* has the second, third, and fourth cheek-teeth proportionately wider from before backwarks than in either of the other species, and this is due to the somewhat greater development of the hinder depressed space and its inclosing ridge. The second upper (pm. 4), as in other species, is a little smaller than the third or fourth (m. 1 m. 2). The pair of fossil teeth would agree in form with either of these three teeth, as they have the hinder depressed space developed to about the same extent, and consequently the antero-posterior measurement of the crown bears about the same proportion to the rest of the tooth. But in size they agree best with the fourth tooth (m. 2), being rather larger than the anterior teeth. The last upper tooth in the recent specimen has the hinder space much enlarged, so as to form a heel, and thus gives the tooth a greater antero-posterior extent.

The *Spermophilus citillus* has the second upper tooth (pm. 4) of about the same proportions as it has in *S. Altaicus*, but the third and fourth teeth are narrower from before backwards. The fossil teeth are larger than either of these, and seem to me to differ from the second and third, which are most near them in size in the larger development of the hinder space.

The only American *Spermophilus* which I have had the opportunity of examining was the *S. lateralis*, and this had the upper teeth of a different pattern, and quite unlike the European forms, or this fossil.

### COMPARATIVE MEASUREMENT OF THE FOUR LOWER MOLARS.

| | | |
|---|---|---|
| Dr. Falconer's, *S. erythrogenoides* | 13·4 | mm. |
| Dr. Nehring's *S. Altaicus*, No. 1. | 11·5 | ,, |
| ,, ,, No. 2. | 11·3 | ,, |
| Brit. Mus. recent *S. Altaicus*, No. 1. | 11·0 | ,, |
| ,, ,, ,, ,, No. 2. | 10·2 | ,, |
| Dr. Nehring's *S. citillus* | 8·5 | ,, |
| Brit. Mus. recent *S. citillus* | 8·5 | ,, |
| Coll. Surg. recent *S. Mongolicus*, No. 1. | 10·2 | ,, |
| ,, ,, ,, ,, No. 2. | 9·2 | ,, |
| Norfolk fossil form at least | 11·5 | ,, |

Unfortunately, I have been unable to see any skeleton of *Spermophilus Altaicus* in order to compare the vertebra (Fig. 9) and foot bones (Figs. 10—13) found with the teeth. The caudal vertebræ of the *S. Mongolicus* in the Royal College of Surgeons, which is the nearest form I have been able to compare the fossil vertebra with, are rather smaller, and of different proportions; but so nearly the same that there is every probability of the fossil being found to agree with the *S. Altaicus*, when recent skeletons of that species are available for comparison. The common Squirrel, with which I was in the first place led to compare these fossil remains, has the caudal vertebræ of quite a different form. With regard to the foot-bones, the proximal and middle phalanges (Figs. 10—11) are shorter and thicker than obtains in the Squirrel; while. although rather larger, they have the same proportions as in the *Spermophilus Mongolicus*. The ungual phalanges (Figs. 12—13) likewise agree with the *Spermophilus*; those of the Squirrel being more curved and compressed.

The comparison of these fossil remains seems to me to indicate such a much closer agreement with the *S. Altaicus* (= *S. Eversmanii*) than with any other available recent form, that I feel justified in referring them provisionally to that species; and none of the characters presented by these fossils militates against the probability of this allocation being correct. Dr. Nehring, in his interesting paper on *Spermophilus*, above referred to, says, "All the fossil *Spermophili* at present found show, that in the period immediately succeeding the Glacial epoch, and perhaps also in the last part of that period, the genus lived in numbers in the plains and hilly regions of Middle Europe and extended into France, Belgium, England, and Denmark." To this we may now add, that, the genus is known to have existed in East Anglia at the beginning of the Glacial Period, and before the deposition of the Till.

## EXPLANATION OF PLATE II.

*Spermophilus Altaicus?* from the Arctic Freshwater Bed, beneath the Glacial Till, near Mundesley.

Fig. 1. Left upper molar (m. 1 or m. 2) grinding surface.
,, 1*a*. Same tooth, view of inner side.
,, 2. Right upper molar (m. 1. or m. 2) grinding surface.
,, 3 & 4. Left and right lower premolar 4, ,, ,,
,, 5 & 6. ,, ,, true molar 1 ,, ,,
,, 7 & 8. ,, ,, ,, 2, ,, ,,
,, 9. Caudal vertebra, seen from below.
,, 9*a*. Same specimen, front view.
,, 10. Proximal phalanx of a digit, seen from above.
,, 11. Middle ,, ,, ,,
,, 12. Distal ,, ,, ,,
,, 12*a*. Same specimen, side view.
,, 13. Another smaller distal phalanx, side view.

Figures 1 to 8 are enlarged 6 times; and 9 to 13 are enlarged 4 times.

## III.—Some Points in the Geology of Anglesey.

By C. Callaway, M.A., D.Sc. (Lond.), F.G.S.

I DO not hesitate to say that Dr. Roberts could not have written the letter which appears in this Magazine for December, 1881, if he had read my papers on Anglesey with care. Not only does he confound together things which I have expressly made to differ, but he attributes to me opinions which never existed in either my thoughts or my writings. I must remove some of these misapprehensions, before discussing the real questions in dispute.

1. Dr. Roberts refers to the grit in the quarries near Nebo, "which," he says, "Dr. Callaway has mistaken for granitoidite." I do not think that any selection of words in our language could more emphatically contradict this singular misstatement than the following quotation from one of the very papers from which my critic is supposed to have derived his information:—"I could find *no granitoid* rock in these quarries, but the ordinary granitoidite occurs on about the same horizon, one-third of a mile to the north-east."[1] On the same page, I refer to the rock as "quartzose grit" and "quartzose conglomerate," descriptions which Dr. Roberts himself adopts.

2. Dr. Roberts discusses the contorted rocks of Northern Anglesey, "which," he affirms, "Dr. Callaway has included under the head metamorphic." Again we have:—"This area of so-called metamorphic rock." And that his readers may be thoroughly impressed with my error, he further on reiterates, "which Dr. Callaway has included under the head metamorphic," and more to the same effect. All this is pure error. Referring to one of my papers on Anglesey, my critic will see that over a page[2] is occupied in showing that the rocks in question are, on the whole, *not* metamorphic, but sometimes unaltered, sometimes partially altered, sometimes metamorphic. On the next page, they are summarized thus:—"The northern area is thus seen to consist of chloritic schists, felspatho-quartzose grits, felspathic shales, chloritic slates, quartz-conglomerates, and grey limestones, with some hornstone[3] bands at more than one horizon." Out of these *seven* types, only *one* (chloritic schist) has undergone thorough metamorphism. A little further on (p. 229), I include these strata in my "Slaty Series," which I describe as "hypometamorphic, a term used to express a *partial* change."

It is more satisfactory to come to genuine criticism. Dr. Roberts objects to my statement "that *in no case* are there any signs of a transition between altered and unaltered beds." He "imagines" that I refer to Northern Anglesey only, but a writer's own words are a safer guide than his critic's imagination. I made no such limit. I used such phrases as "the altered rocks of Anglesey," and "many parts of Anglesey." But I will confine myself to the northern area, since Dr. Roberts finds it more convenient. In opposition to my views, he announces that he is "in a position to state that . . . at two points (at any rate) . . . . a distinct passage can be seen and traced inch by inch from the fossiliferous shales to the beds marked 'altered Cambrian' on the Survey Map." At one of these localities, "the two series can be seen passing into one another, the one dipping under the other." Dr. Roberts contents himself with a "passage" at "two points." I could have told him of dozens of such "passages." Every one familiar with Archæan work knows that *taken alone* they prove nothing. The unaltered beds are let down by faults, and, when the dips are the same (which is often the case in the north of the island, though less frequent in the west), the newer rocks appear to pass conformably under the older. It is unsafe to affirm a passage between two groups, unless there is a gradation in mineral characters and, when one is altered, in state of alteration; but Dr. Roberts asserts neither of these conditions. It needs double caution in working on his method when the upper group is more highly altered than the lower, since the theorist must be prepared to consider why the metamorphism did not affect the lower series, and why, in its supposed downward progress, it stopped abruptly. During several months of close work, undertaken at intervals extending through the last three years, I have examined scores, if not hundreds, of junctions between altered and unaltered groups in Anglesey, and the line of separation was invariably clear and sharp. It is incredible that such should have been my experience, had a true passage existed.

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[1] Geol. Mag. March, 1880, p. 118.

[2] Quart. Journ. Geol. Soc. vol. xxxvii. p. 223.

[3] Incorrectly printed "limestone."

It is not necessary to review the general question of the Archæan age of the altered and contorted rocks of Anglesey. I will content myself with stating that when Dr. Roberts has *thoroughly* explored the island, he will find that the Cambrians contain fragments derived from his "gnarled series." This will place him in a rather awkward dilemma.

My critic's confused views of the Anglesey Archæans appear to have originated in the assumption that all his "gnarled" rocks belong to one series. I have given reasons for believing that there are *two* contorted groups; the one newer than the granitoidite, and hypometamorphic; the other underlying the granitoidite, and metamorphic. The latter rocks occupy the area west of the Menai Straits, a part of the Central Zone, and the west of the island as far north as the Porth-y-defaid fault. They differ widely from the northern group and the series west of Malldraeth Marsh, in both mineral characters and degree of alteration. The rocks of the north are by my critic's admission not entitled to be called "metamorphic," and that I am not alone in applying that term to the Menai and Holyhead schists will appear from the following quotation from a letter by Prof. Bonney, F.R.S., whose competence as a microlithologist will hardly be questioned.

"I have not yet seen enough of the extremely difficult geology of Anglesey to enable me to commit myself to any opinion beyond the assertion that this island contains a large tract of metamorphic rock of Pre-Cambrian age; neither will I venture to discriminate between the various rocks which may have been included in the 'gnarled series,' though I think it likely that field observers may have included in it rocks very different in their real mineral character. But I will assert that the schists on the Anglesey shore, near the Menai Bridge, those in the neighbourhood of the Valley station, and those near the town of Holyhead, thoroughly deserve the title of metamorphic rocks. I believe the idea that these or their equivalents are of Bala age has been called 'a working hypothesis.' To myself, who have taken some pains to study rocks, especially of this class, it is about as valuable as one would be that for stratigraphical purposes paid no attention to the species of fossils."

Prof. Bonney also permits me to quote an extract from another letter, in which, referring to my opinion that in the central area, which he had just examined, the dark-green hornblendic and chloritic schists pass below the granitoidite, he says:—"I must say that the evidence in favour of your view appears to me very strong."

I did not reply to Dr. Roberts' paper on Twt Hill (Geol. Mag. May, 1881), because the matter in dispute was one for which I was responsible in a very secondary degree. I should be greatly relieved if he could prove the Cambrian age of the conglomerate, since it contains pebbles of gneiss undistinguishable from the grey variety round Gwalchmai. This fact has always been a stumbling-block to me. If this conglomerate is Cambrian, the difficulty is removed, and we are furnished with an additional proof of the Pre-Cambrian age of the gneissic series.

Dr. Roberts, in his concluding paragraph, asserts that I have misapprehended *some* of the most important sections. He then attempts to prove this rather formidable proposition by giving *one* example: the section near Nebo. Passing over this numerical inconsistency, I will content myself with reaffirming my opinion. I have always been perfectly aware that the black shale is faulted against the grit. Indeed, in my note-book, I find a section (dated July 20, 1880) which is almost a *facsimile* of the figure in Dr. Roberts' paper.[1] My view always has been that the shales were originally unconformably deposited on the grit, and that the latter was afterwards thrust up through the shales, which were thrown off in various directions, but a part remained on the grit, lying in denuded hollows. I freely admit that some eccentric lateral movements *may* have produced the appearances described, and in Anglesey one is surprised at nothing; but at present I prefer to adhere to the more natural interpretation.

As I am writing, I may as well refer to some points discussed in Dr. Roberts' former paper. He attempts to prove that the conglomerate at Penlon is Cambrian, because, as he asserts, there is an unbroken succession down into it from the Cambrian shales. I confess myself puzzled with his mode of working. The exposures are few and distant, especially in the area north of the quarry, where they are most wanted. How one formation can be "traced down" into another on such evidence as this, requires explanation. Anglesey, especially in this part of the island, is so thickly scored with faults, that no efforts of the imagination are admissible.

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[1] Geol. Mag. May, 1881, p. 197.

The rock at Bryngwallen, which Dr. Roberts wishes to correlate with the Twt Hill conglomerate, is undoubtedly Cambrian; but the lithological resemblances between the two types are by no means striking. They are alike in containing pebbles of vitreous quartz, but this mineral is too widely distributed to prove much.

The other inclosed fragments do not correspond; the Twt Hill rock containing jasper, quartzite, and schist, while the Bryngwallen conglomerate, besides the quartz, incloses, so far as I could find, only felsite pebbles, which alone would be sufficient to suggest a Post-Archæan age. It is curious that Dr. Roberts should maintain that "the absence of felsite pebbles" in this rock "removes the only really strong *à priori* argument against referring the Twt Hill bed to the Cambrian series;" when almost the first blow of my hammer, on my visit to the quarry, struck off a piece of conglomerate containing at least one felsite pebble.

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## IV.—SUPPLEMENT TO A CHAPTER IN THE HISTORY OF METEORITES.

By WALTER FLIGHT, D.Sc., F.G.S.

IN the volume of the GEOLOGICAL MAGAZINE which appeared in 1875, I published a digest of the literature relating to the meteorites which fell between 1869 and that date, as well as an examination of the work done during that interval of time on meteorites which had fallen before 1869. I purpose now to direct the reader's attention to what has happened or been done during the intervening years, 1875 to 1881, and bring the supplement down to the present time.

### Found 1870.—Ovifak, Disko, Greenland.[1]

M. Daubrée gives the name *Lawrencite* to the iron protochloride, the presence of which he has detected in the curious meteoric irons of Ovifak. It was earlier recognized in the Tennessee meteoric iron by Dr. Lawrence Smith.

The Academy of Sciences of Paris appointed a commission to report on a paper by Dr. Lawrence Smith on the supposed native iron of Greenland, and their report has recently been presented by M. Daubrée. It is pointed out that the bodies which come from beyond our atmosphere, and which are called meteorites, present, as regards their mineralogical constitution, a most striking resemblance to certain terrestrial rocks. The important fact that masses derived from most widely separated regions of space should present such resemblances was pointed out by Nordenskjöld in 1870, when he discovered large masses of native iron at Ovifak, on the island of Disco, Greenland. The first thought which suggested itself to him was that they were of meteoric origin. In order to explain the fact that these masses were fused into the basalt, he assumed that they had fallen into it while it was still liquid. Many adopted this view, and, among others, Nauckhoff and Tschermak. Steenstrup, on the other hand, after visiting the locality twice, came to the conclusion that they were masses of native iron, and that they had the same terrestrial origin as the basalt itself. Not far from Ovifak, in the Waigatstrasse, Steenstrup found evidence which supported this theory: in the basalt of Igdlokungoak he hit upon a mass of metalliferous magnetic pyrites weighing about 28,000 kilog., and again, in the basalt of Aussuk, small grains of native iron. The graphite associated with this iron pointed to the probability that carbonaceous substances had reduced this metal; moreover, the rock enclosing the native iron contained the silicate of ferric hydrate which has received the name Hisingerite. With these opposing views so plainly set forth, Dr. L. Smith has gone over the whole question, and comes to the same conclusion as Steenstrup, that the masses of metal are of terrestrial origin. He finds that in the dolerite of Aussuk, as well as that of Ovifak, which it closely resembles, metallic iron is found enclosed in labradorite; anorthite is likewise found in certain parts of the mass of the rock, and oligoclase also.

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[1] G. A. Daubrée, *Compt. rend.* 1877, Jan. 8th, lxxxiv. 66; *Ibid.* lxxxvii. 911.

Iron has been obtained from seven localities in Greenland: from Sowallicke, Fiskenäs, Niakornak, Glück's Bay, Jacobstown, Ovifak, and Aussuk. The iron of Sowallicke and Niakornak is found by Dr. L. Smith to contain combined carbon, just as the Ovifak iron does; in fact, he states that all specimens of iron obtained from Greenland are similar in this respect, and differ from meteoric iron, which contains no combined carbon; moreover, these masses all contain cobalt in considerable quantity in relation to nickel. Dr. Smith next refers to the similar geological character of the area where the iron has been found, it being found only in the basalt region, which extends from 69° to 76°, where it disappears under a huge glacier. We shall probably never know how wide the extent is of this volcanic area which stretches far away north; that, however, which has been seen represents an area equal to one extending from Gibraltar to Brest. We know that the terrestrial rocks which present the closest resemblance to the meteoric rocks belong to the lowest beds of the earth. Some are eruptive rocks of a basic character, consisting of anorthite and augite, like certain lavas from Iceland; others are of olivinous rocks, like lherzolite, to which the meteorites containing magnesia—those, in fact, of the ordinary type—belong. The gangue of olivinous rocks accompanying the platinum of the Urals, and the presence of nickel in the native iron combined with the platinum, have confirmed these relations, which are of interest alike for the geologist and the astronomer. It was expected that among the aluminous and magnesian rocks some might be found in which iron should begin to make its appearance, and this gap has now been filled. In the Greenland beds layers of lignite are found associated with the basalt, and this may have furnished the material which has reduced the iron to the metallic state.

### Found 1872.—Neuntmannsdorf, near Pirna, Saxony.[1]

This mass of meteoric iron was found in 1872, and a superficial examination of it by Lichtenberger was made in the following year ("Sitzungsber. der Isis," Dresden, 1873, p. 4). It is a rounded block of malleable iron, weighing 25 pounds, and covered with a blackish-brown crust of oxide. Like the meteoric irons of Ovifak, Disko Island, Greenland, and many others, it contains chlorine, and in damp warm air rapidly oxidises and exfoliates. The metal has the grey colour of iron, does not exhibit the Wiedmannstättian figures, and has a specific gravity of 6·21 Geinitz finds the composition of this iron to be—

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[1] F. E. Geinitz, *Jahrbuch für Mineralogie*, 1876, p. 608.

| | |
|---|---|
| Iron ... ... ... ... ... ... ... | 93·04 |
| Nickel ... ... ... ... ... ... ... | 6·16 |
| Phosphorus ... ... ... ... ... ... | 0·22 |
| | 99·42 |

In the iron are many rounded, sometimes elongated, hollows filled with a yellowish-brown mineral having the specific gravity=3·98. This on analysis was found to consist of—

| | |
|---|---|
| Iron ... ... ... ... ... ... ... | 63·82 |
| Sulphur... ... ... ... ... ... ... | 37·36 |
| | 101·18 |

which showed it to be troilite (iron monosulphide), and to accord in composition with the sulphide found in the meteoric iron of Seeläsgen. One cavity was filled with what appeared to be the same mineral in a crystalline form. This is the first occasion where troilite has been met with otherwise than massive.

### Found August, 1873.—Duel Hill, Madison Co., N. Carolina.[1]

A mass of meteoric iron was found in August, 1873, on the land of Mr. Robert Farnesworth, lying on a hill-side, where it had been used probably by the first settlers to support a corner of a rail fence since rotted away. (A similar block, weighing about 40lb., was discovered about a mile further west, "before the war, perhaps about 1857," but has since been covered over and lost.) The mass above referred to originally weighed some 25lb.; but specimens have been hammered off it, and it now weighs 21lb. and measures 9 × 6½ × 3½ inches. It has the usual coating of magnetite, and from various points of the surface bead-like drops of iron chloride exude. When polished and etched, "the usual markings appeared, though rather indistinct," and when the action of acid was prolonged distinct particles of Schreibersite were seen to protrude from the face of the metal. The meteorite has a specific gravity=7·46 and the following composition:—

| | |
|---|---|
| Iron ... ... ... ... ... ... ... ... | 94·24 |
| Nickel ... ... ... ... ... ... ... ... | 5·17 |
| Cobalt ... ... ... ... ... ... ... ... | 0·37 |
| Copper ... ... ... ... ... ... ... ... | *Trace* |
| Phosphorus ... ... ... ... ... ... ... | 0·14 |
| Residue... ... ... ... ... ... ... ... | 0·15 |
| | 100·07 |

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[1] B. S. Burton, *Amer. Journ. Sc.* 1876, xii. 439.

### 1873.—Chulafinee, Cleborne Co., Alabama.[1]

The writer refers to a mass of iron which was found in 1873, and supposed at the time to be a specimen of bog iron-ore. It was taken to a blacksmith, who managed to remove a piece weighing 3¼ lbs., which was wrought into horseshoe nails and a point for a plough. It remained where it was found till last year, when it was sent to Menlo Park. It weighs 32½ lbs., and its form, as well as the character of an etched surface, are shown in woodcuts accompanying the paper. An analysis shows it to contain iron and nickel, with a little copper, phosphorus, and carbon: it is being made in duplicate, and will be published later on. The Wiedmannstättian figures are well developed.

### 1874. April 10th, 7·57 p.m. (Prague mean time). Bohemia.[2]

A detonating meteor; conforms in radiant-point with that of 1876, April 9th.

### 1874. May 14th, 2·30 p.m. Castalia, Nash Co., N. Carolina. [Lat. 36° 11′, Long. 77° 50′.][3]

A short notice in Silliman's Journal states that the descent of these meteorites, numbering a dozen or more, was accompanied with a series of explosions and rumbling noises which lasted about four minutes, and were "not unlike the discharge of firearms in a battle a few miles off." Although the fall took place by day, a luminous body was observed. The area over which the fragments fell was ten miles long and three wide. Three stones, weighing 5·5, 1·0, and 0·8 kilog., have been found. The dull-coloured crust does not entirely cover the stones, the fused matter forming it being scattered over some small parts of the surface in the form of pear-shaped beads; in one or two crevices the fused material has penetrated 5 millims. below the surface, and here it is more brilliant than on the surface.

The colour of the interior is in many parts of a dark grey, owing to the presence of a larger amount of nickel-iron; in the lighter portions are seen some white spots of a mineral that is doubtless enstatite. The specific gravity of the stone is 2·601, and its proximate composition:—

| | |
|---|---|
| Nickel-iron | 15·21 |
| Soluble silicate | 44·92 |
| Insoluble silicate | 39·87 |
| | 100·00 |

The metallic part consists of—

Iron = 92·12; Nickel = 6·20; Cobalt = 98·73;

and the siliceous portions of—

| | $SiO_2$ | $Al_2O_3$ | FeO | MgO | $Na_2O$ | S | |
|---|---|---|---|---|---|---|---|
| A. Soluble...... | 38·01 | 0·46 | 17·51 | 41·27 | ...... | 1·01 | = 98·26 |
| B. Insoluble... | 52·61 | 4·80 | 13·21 | 27·31 | 1·38 | ...... | = 99·31 |

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[1] W. E. Hidden, *Amer. Journ. Sc.* 1880, xix. 370.

[2] Prof. G. von Niessl, *Sitzungsber. Akad. Wiss. Wien*, lxxv. April 19th, 1877.

[3] J. L. Smith, *Amer. Journ. Sc.* [3] viii. 147.

The soluble silicate is an olivine in which the ratio of MgO to Fe is about 4 : 1; the insoluble is a bronzite; and in addition to the minerals already mentioned, the presence in the Castalia stones of small amount of iron sulphide and anorthite was recognized.

### 1874. November 26, 10.30 a.m.—Kerilis, Commune de Maël-Pestivien, Canton de Callac (Côtes-du-Nord).[1]

A great noise, lasting two minutes, and resembling a peal of thunder, was heard at this date at Maël-Pestivien, and for ten kilomètres around. At the same instant a workman near the village of Kerilis saw the earth struck, at a spot 12 mètres distant, by what he believed to be thunder. He visited the spot the next day, and found a meteorite at a depth of 0·78 mètre. The stone weighed 5·000 kilogrammes, and is covered with a remarkably thick black crust: a number of fragments were detached from the stone till its weight was reduced to 4·200 kilogrammes; it then passed into the hands of a clergyman, who bought it and presented it to the Natural History Museum of Paris.

A freshly broken surface of the stone shows a mottled and striated surface, with metallic grains of nickel iron; the surface is of a deep grey colour with ochre-coloured spots, due doubtless to traces of iron chloride. The individual grains vary in size; some, the largest, are chalk-white, the most numerous are of an ashy-grey; here and there rounded grains (the chondra of Gustav Rose) are apparent, as well as yellow or bronzy grains of pyrrhotine. The grains of nickel iron are very small. The density of the meteorite is 3·51. By the action of hydrogen chloride 60 per cent. of the stone dissolves: this consists of olivine, nickel iron, and pyrrhotine; the residue under the microscope is found to consist of a great number of crystalline grains. much acted upon by polarised light, and some of which show the forms of the prism; others show the cleavage which indicates enstatite. Besides these are black grains of chromite with an octahedral contour.

This stone most closely resembles those of Limerick (Adare) which fell 1813, September 10th, and Ohaba, Siebenbourg, 1867, October 10th, and belongs to the group of Sporadosideres and the sub-group Oligosideres.

### Found 1874.—Waconda, Mitchel Co., Kansas.[2] [Lat. 39° 20′, Long. 98° 10′.]

This meteorite was found in 1874, lying above ground upon the slope of a ravine about two miles from the village of Waconda. Fragments amounting to about one-half of the stone were removed at the time; the remainder, weighing about 58 lb., is partially covered with a black crust. The freshness of the original fracture, at the time when the stone was submitted to examination, points to the fall being one of recent date.

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[1] *Ibid.* p. 28. M. Daubrée, *Compt. rend.* 1880, xci. 28.

[2] C. U. Shepard, *Amer. Journ. Sc.* 1876, xi. 473. See also J. L. Smith, *Amer. Journ. Sc.* 1877, March, xiii.

It closely resembles the stone of Searsmont (21st May, 1871) in colour, but is less chondritic, and only exhibits this characteristic of certain meteorites in a very imperfect manner. Crystals of what appear to be augite are observed imbedded in an amorphous whitish ground-mass; nickel-iron is present thickly scattered throughout the stone in minute rounded lustrous grains; while troilite is now and then met with in grains of considerable size or aggregations of imperfect crystals. A fragment partially covered with crust was found to have a specific gravity = 3·81; that of another fragment without crust was = 3·58.

Mechanical separation of the ingredients was attempted, and 5·66 per cent. of nickel-iron and 1·34 per cent. of troilite were isolated. Of the remaining siliceous portion rather more than one-half gelatinized with acid, and was, presumably, olivine; the remainder, according to Prof. Shepard, consists of "augite, some felspathic species, and chladnite," by which last mineral enstatite presumably is meant. There exists a rumour that a second meteorite has been met with twelve miles distant from the above.

Dr. Lawrence Smith found the density of this stone to vary from 3·4 to 3·6 and its composition to be:—

Stony matter = 90·81; Nickel-iron = 5·34; and Troilite = 3·85.

The nickel-iron contained:—

Iron = 86·18; Nickel = 12·02; Cobalt = 0·91; Copper = 0·04.

and the stony part consisted of:—

Soluble part = 59·00; Insoluble part = 41·00.

which are made up of—

| | Soluble. | Insoluble. |
|---|---|---|
| Silicic acid | 34·52 | 54·02 |
| Iron protoxide | 30·01 | 18·10 |
| Alumina | 0·43 | 2·30 |
| Magnesia | 32·50 | 23·45 |
| Manganese | 0·61 | 0·36 |
| Soda, with trace of potash and lithia | 0·89 | 1·58 |
| Lime | | *Trace.* |

The analysis clearly shows that the stony part of this meteorite consists of the usual mixture of olivine and pyroxene; the hydrosiderite predominating in the former and bronzite in the latter.

Two minerals were detached in small quantities and analyzed separately. The first was a dark-coloured mineral readily seen in small parcels or veins; it was almost entirely decomposed by hydrogen chloride; its composition was:—

| | |
|---|---|
| Silicic acid | 41·10 |
| Iron protoxide | 27·20 |
| Alumina | 0·80 |
| Magnesia | 28·31 |
| Manganese | 0·32 |
| Soda | 1·35 |

It clearly belongs to the olivine type. The other mineral was found only in one part of the specimen which reached Dr. L. Smith; it formed a white crystalline mass, and weighed about 20 millegrammes. It resembled enstatite, but was completely decomposed by hydrochloric acid, and as far as he could judge consisted only of silicic acid and magnesia. It appears to occupy the same place among the unisilicates as enstatite does among the bisilicates, but requires further examination.

### 1875. February 12th, 10·30 p.m. (Chicago time). Iowa Co., State of Iowa.[1]

A very large and brilliant fireball passed over Iowa City at the above date, in a direction slightly N. of W.; the apparent size of the meteor was about half that of a full moon, and it was accompanied by a broad train of light of a slightly green hue. Three separate explosions of the fireball were noticed while it was still in view, and about two or three minutes after it disappeared three reports, resembling the discharge of the blast of a quarry, were heard.

The phenomenon attracted general attention throughout several counties in the central part of the State of Iowa; and although the visible path of the meteor does not appear to have exceeded 50 to 60 miles, the occurrence attracted attention and was heard over an area measuring about 125 miles from E. to W., and half that distance from N. to S. An observer at Brooklyn was aroused from his bed by the report; and another, who was riding in a sleigh near West Liberty, 40 miles E. of the spot where the stones fell, states that objects were rendered about as visible as if it were day, the explosions being loud, and followed by a rumbling sound that lasted some 60 or 90 seconds. According to the *Grinell Herald*, the interval, as observed at that town, between the light of the meteor being seen and the report being heard was three minutes. The *Des Moines Register* states that between Red Rock and Newton some of the meteorites passed so near the earth's surface that they clipped off branches from the trees.

Prof. N. R. Leonard, of the Iowa State University, states that the meteorites weighed altogether about 250 lbs., whereof 141 lbs. came into his possession; Prof. Hinrichs makes the total weight about 300 lbs. The largest mass, which was broken in falling, weighed 43½ lbs., the chief fragments, found together, being 20 lbs. and 16lbs. in weight.

According to a description, of a very sensational character, which is given in the *Dubuque Times*, one of the meteorites was found in a field about three miles S. of the village of West Liberty, having penetrated, so it is stated, to a depth of fifteen feet into the ground.

The *Davenport Gazette* states that another stone fell at Homestead, near Iowa City (lat. 41° 46′ N., long. 92° 0′ W.), in a field covered with ice and snow, and rebounded in a N.E. direction for a distance of more than thirty feet up a slight declivity, where it came to rest in the sand, which was fused and adhering to it. It weighed originally about 7 lb. 6 oz., but had been reduced by eager curiosity-hunters to 3 lb. 8 oz.; the fractured surface of this meteorite had a dark and less distinct coating than that belonging to the larger block from which it had been detached by the explosion.

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[1] A. W. Wright, *Amer. Journ. Sc.* ix. 459, and x. 44; J. W. Mallet, *Amer. Journ. Sc.* 1875, x. 206; N. R. Leonard, *ib.* x. 357; A. W. Wright, *Amer. Journ. Sc.* 1876, xi. 253; *An Account of the Detonating Meteor of February* 12, 1875, by C. W. Irish, Iowa City, 1875, *Daily Press* Job Printing Office, Dubuque Street; M. Delafontaine, *Bibliothèque Universelle*, October, 1875, 188; G. A. Daubrée, *L'Institut*, 1875 (Nos. 105-122), 138; C. W. Gümbel, *Sitzungsber. Ak. Wiss. München*, 1875, v. 313.

The stones are covered with the usual black crust, and there is evidence on some of the pieces of the meteorites of the fused material of the outer portion having run partially over the freshly fractured surfaces. Some fragments show distinct evidence of a sort of lamination or imperfect stratification, the parts where the surfaces cleaved being smoothed down as if by pressure or friction. About 100 were found, varying in size from 9500 to 50 grammes, 25 kilogs. having been sent to Paris. A preliminary chemical examination of this meteorite has already been made by L. Smith, who finds the specific gravity to be 3·57, and the composition:—

Nickel-iron = 12·53; Troilite = 5·82; Silicates = 81·64: total 100·00.

The nickel-iron consists of—

Iron = 89·04, Nickel = 10·35, Cobalt = 0·54: total 99·93,

with traces of copper, phosphorus, and sulphur. The silicate contains iron protoxide, alumina, magnesia, soda, with traces of lithia and potash, and has, according to L. Smith, very similar compositions to the meteorite of New Concord, Guernsey Co., Ohio (1860, 1st May). Daubrée remarks on its chondritic structure, and considers it to belong to a large class of meteorites, notably represented by the stones which fell at Vouillé (1831, May 31st) and Aumale Algeria (1865, August 25th).

This meteorite being of the stony kind, and having so recently fallen, it occurred to Wright (see also the examination of the Texas Meteorite)[1] to examine the gases contained in the particles of iron distributed throughout its mass, with a view to learning whether they present the same characters as the gases occluded by the iron forming large and independent masses.

He extracted from this picked iron at a moderately elevated temperature several times its volume of gas, consisting of 35 per cent. of carbonic acid, 14 per cent. of carbonic oxide, the remaining 51 per cent. being chiefly hydrogen. These results were obtained from metallic portions removed with the magnet: the pulverized rocky residue, however, retained a considerable amount of iron in too finely divided particles to enable them to lift the stony fragments adhering to them; accordingly a piece of the solid meteorite, about four cubic centimètres in amount, was reduced to powder and placed in the tube attached to the pump. The warmth of the hand sufficed to disengage some little gas, which, when tested, was found to contain carbonic acid and hydrogen. The pump was then set in action, and heat applied to the tube in the following manner:—I. The temperature of boiling water continued for several hours. II. The moderate heat (200°–250°) of a small Bunsen flame applied for a short time. III. A stronger heat, kept below visible redness, applied for nearly an hour. IV. Low red heat maintained about half an hour. V. Full red heat. The total amount of gas evolved was about two and a half times the volume of the material operated upon, and twenty times that of the iron. The following are the relative proportions of the gases obtained at different temperatures:—

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[1] Geol. Mag. 1875, Decade II. Vol. II. p. 364.

| | I. At 100°. | II. At 250°. | III. Below red heat. | IV. At low red heat. | V. At full red heat. |
|---|---|---|---|---|---|
| Carbonic acid ............ | 95·46 ... | 92·32 ... | 42·27 ... | 35·82 ... | 5·56 |
| Carbonic oxide ......... | 0·00 ? ... | 1·83 ... | 5·11 ... | 0·49 ... | 0·00 |
| Hydrogen ............... | 4·54 ... | 5·86 ... | 48·06 ... | 58·51 ... | 87·53 |
| Nitrogen (calculated) ... | 0·00 ... | 0·00 ... | 4·56 ... | 5·18 ... | 6·91 |
| | 100·00 | 100·00 | 100·00 | 100·00 | 100·00 |

As regards the gas they occlude, iron and stony meteorites show a marked distinction. While the gases of the Lenarto iron contained 85·68 per cent. of hydrogen, those obtained from cosmical masses of the stony kind, if the Iowa meteorite may be regarded as a type, are characterized by the presence of carbonic acid, which constitutes nine-tenths of the gas evolved at a temperature of boiling water, and about one-half of that given off at a low red heat.

The spectrum of the gas of the Iowa meteorite, when the pressure of the pump was high, gave very brilliant carbon bands, the hydrogen lines being weak and comparatively inconspicuous, although at a very low pressure they became relatively stronger. The brightest carbon bands were the three in the green and blue, the red one being much feebler. These are precisely the ones most conspicuous in the spectra of some of the comets; and this fact is a remarkable confirmation of the received theory as to the meteoric character of those bodies.

This, moreover, is a very significant fact in showing that it is quite unnecessary to assume the existence of volatile hydrocarbons to explain cometary spectra, as some writers have done, and that the presence of the two oxides of carbon in such quantity is quite sufficient to account for all that has been observed when we consider the circumstance that the tension of the gases of the cometary appendage must be extremely small. Were a large comet to approach near enough to the sun to have its nucleus intensely heated, it is highly probable that, over and above the bands already observed, the hydrogen lines would be found in its spectrum.

Wright expresses regret that such a comet as Donati's should have departed into space just early enough to escape observation with the spectroscope. While the most probable cause of the emission of light under these conditions is electricity, another may be found in the property of gaseous bodies of emitting light of the same character as that which they absorb. It is not altogether improbable, Wright suggests, that the solar radiations absorbed by the gaseous matter, although for the most part converted into heat, would also in part be emitted again as light, and that in the case of volumes of gas filling many cubic inches, the intensity might be sufficient to give a distinct spectrum of broad bands or lines, even though, on the scale of any possible experiment, no trace of such action can be detected. These researches have led the author to accept the following conclusions:—

1. The stony meteorites are distinguished from those which are metallic by occluding the oxides of carbon, chiefly carbonic acid, as their characteristic gases, in place of hydrogen.

2. The proportion of carbonic acid evolved is much greater at low than at high temperatures, and is sufficient to mask the hydrogen in the spectrum.

3. The amount of gas contained in a large meteorite, or a cluster of such bodies serving as a cometary nucleus, is sufficient to form the train as ordinarily observed.

4. The spectrum of these gases closely resembles that of several of the comets.

The emission of gaseous constituents by the action of solar heat may explain the loss of tail and the diminution of brilliancy observed in the case of several comets in their successive revolutions; and their final disappearance from sight will follow as an inevitable consequence, the number of revolutions necessary to discharge the gases depending chiefly on their size and the nearness of their approach to the sun at their perihelia. When a meteorite enters our atmosphere, the gases which are evolved from it by the heat which is liberated must greatly contribute to increase the intensity of that heat, while the sudden expansion which these gases experience must constitute the leading cause of the violent disruption of these masses.

The conclusions arrived at by Wright, on examining the gases occluded by the iron of these meteorites, have been referred to. He considered that the stony meteorites were distinguished from the iron ones by having the oxides of carbon, chiefly the dioxide, as their characteristic gases instead of hydrogen. This theory has been called in question by Mallet, who refers to his examination of the gases of the iron of Augusta Co., Virginia, where the ratio of the oxides of carbon to hydrogen is 4 : 3, and to his having pointed out in 1872 that hydrogen could no longer be regarded as *the* characteristic gaseous ingredient of meteoric iron. In his paper of that date he stated that although it might be assumed that carbonic oxide would be the original form in which the gaseous carbon-compounds existed in the iron, and that it broke up at the temperature of the experiment into carbon retained by the iron and into carbonic acid, yet in view of the steady decrease of the quantity of the latter gas which was evolved as the experiment proceeded, it seems more likely that a larger amount of carbon originally existed in the higher state of oxidation. Mallet considers that, when all the circumstances of the experiment are considered in each case, Wright's conclusion cannot be sustained.

In a paper dated some months later, Wright replies to Mallet's criticism. He states that he only meant this expression of opinion to be tentative, but that the results of further work completely justify the conclusion at which he had arrived. He has re-examined the gases of the iron of this meteorite, and examined those of the iron of some other stony meteorites, such as Ohio, Pultusk, Parnallee, and Weston, and finds that not only do the stony meteorites give off a much larger volume of gas at low temperatures, but the composition of the gas in all the cases studied is quite different from that evolved from meteoric iron. In no case among the results obtained with the alloy is the amount of carbonic acid greater than 20 per cent. at 500°, nor than 15 per cent. of the whole quantity evolved, while in every case but one the volume of carbonic oxide is considerably larger. In the chondritic meteorites, on the other hand, the per-centage of the latter gas is conspicuously small, while the carbonic acid constitutes more than half the total gas evolved below a red heat, except in the case of the meteorite under consideration which fell at Iowa, and here the per-centage is not much less, especially if we reject the numbers representing the amount obtained by a second and long-continued application of a red heat. At a temperature of about 350° it constitutes from 80 to 90 per cent. of the gaseous products, and at 90° it forms more than 90 per cent. of the gas evolved. The hydrogen, on the other hand, progressively increases in quantity with the rise of temperature, and is the most important constituent of the first portions removed at a red heat. The form in which the carbonic acid is occluded is a problem which he cannot at present solve. That it is actually absorbed appears to be certain. That it has been taken up from the atmosphere has been proposed. He finds, however, that the iron of the Iowa meteorite contains no more carbonic acid now than it did at the time of its fall.

Leonard gives a detailed account of the appearance presented by the meteor, which is stated to have been seen throughout a region 400 miles from S.W. to N.E., and 250 miles in breadth. The stones vary in weight from a few ounces to 74 lbs., and the aggregate weight is 500 lbs.; the area over which they were scattered appears to be seven miles in length, and four miles at its greatest breadth. A plan of the townships included in this area is given in Leonard's paper, and it shows where the chief stones fell. By reason of the frozen condition of the ground at the time of the fall, and the low angle of descent, it appears probable that almost all the fragments which fell have been secured. The velocity of the meteor has not been satisfactorily determined; it appears probable that during the last 60 or 70 miles of its course it travelled at the rate of from six to seven miles per second.

An interesting pamphlet by Mr. Irish, C.E., deals with the appearance presented by the meteor. He has incorporated in his paper a number of letters received from observers stationed over a wide area describing their impressions as to its altitude, velocity and appearance; and he has given a drawing of the meteor, and prepared a map of the district, showing the projection of its path through the air. I learn by a recent letter from Mr. Irish that two blocks, one weighing 72 lbs., the other 48 lbs., which evidently formed one and the same mass which was disrupted during the descent, have since been found; and the aggregate weight of the stones now collected cannot be less than 700 lbs. I am also indebted to Mr. Irish for six excellent photographs of the Iowa stones, sixty-seven in number, which form the collections of Prof. Hinrichs, Mr. J. P. Irish, and himself. They were taken by Mr. Thomas James, of Iowa city, and are in the very best style of photographic art.

Prof. Gümbel, of Munich, has recently published an interesting paper on the characters of this meteorite. He finds the crust to possess a deep bottle-green or brownish-red colour, and to possess in polarized light all the characters of an amorphous glass-like mass. When a fragment is heated, it turns of a dark-brown colour, like that noticed by him in the eruptive rocks of the Fichtelgebirg, and he regards this change as a safe indication of the presence of olivine.

The composition of the stone is found to be:—

| | |
|---|---|
| Meteoric iron | 12·32 |
| Troilite | 5·25 |
| Silicate, decomposed by acid | 48·11 |
| Silicate, not acted upon by acid | 34·32 |
| | 100·00 |

The silicate decomposed by acid is an olivine, having the formula $2\,(\frac{2}{3}\,MgO,\ \frac{1}{3}\,FeO),\ SiO_2$; and the insoluble silicate, which has been regarded by Dr. Lawrence Smith as pyroxene, gave the oxygen ratios—silicic acid = 29·68; bases = 10·29. It appears not improbable that in this case the silicate was not completely decomposed during analysis.

The paper is illustrated with an interesting plate of a microscopic section, showing olivine, augite, meteoric iron, chromite, troilite, particles of a reddish hue which resemble garnet but which doubly refract light and exhibit optical characters which will not allow of their being identified with nosean, and chondra showing fibrous, radiate, and granular structure, as well as others which evidently consist of olivine, and some which are opaque and finely granular. The meteoric iron has a hackly angular structure, and has the appearance which it would present if reduced to the metallic state in the position which it at present occupies.

*(To be continued in our next Number.)*

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## V.—Traces of a Great Post-Glacial Flood.

### I. The Evidence of the Loess.

(*Concluded from* p. 18.)

By H. H. Howorth, F.S.A.

HAVING examined the various theories of the origin of the Loess, which have been current, and found them wanting, I would, with great deference, propose another which has not hitherto been suggested by any geologist, and which offers at least a probable solution of our untractable problem. In previous papers of this series, if we have not proved, as we think we have, that the evidence in favour of the Mammoth and his companions having been suddenly overwhelmed by a great diluvial movement is unanswerable, we claim to have at least shown a very strong *à priori* probability in favour of such a view. If this view is correct, it involves, no doubt, that at the time when the Mammoth was destroyed, there was a great dislocation of the earth's crust in certain neighbourhoods, and corresponding volcanic and other agitation. Proofs that there were such dislocations at this very time on a very wide scale will I trust be forthcoming in a future paper. At present we will localize our problem to the two areas where the Loess predominates, Central Europe and China. First, the European area. There can be small doubt that the volcanos of the Eifel, etc., in the Rhine Valley, were in full activity during and probably also subsequent to the deposit of the Loess. Dr. Samuel Hibbert-Ware, who, in 1832, published his well-known work entitled "History of the Extinct Volcanoes of the Basin of Neuwied on the Lower Rhine," has amply proved this, and it is a most remarkable fact how little use has been made of his careful researches by recent writers on the Loess. The first point which Dr. Hibbert-Ware made clear was, that the deposition of the Rhine Loess took place at the time when the volcanos there were active, just as we know the volcanos of Auvergne were active when the deposits containing Mammoth and other remains were laid down. On pages 201 and 202 of his book may be seen descriptions of sections showing the alternation of Loess, with beds of volcanic ashes, pumice, and white sand. These sections occur near Andernach. I will content myself with quoting one sentence. "From Heddesdorf to Oberbeiber and between Friedrichstein, Fahr. Genersdorf, and Feldkirch, layers of Loess, only a few inches in thickness, are not only observed to alternate with white pumice, but even with black sand. Similar appearances again present themselves at Bendorf, Bassenheim, Octendung, and Obermennig" (*op. cit.* p. 202). Lyell attempts to explain this somewhat overwhelming evidence in another way, but even he says: "The volcanoes of the Lower Eifel seem to have been in eruption in Pleistocene times," and he suggests that some of them were of sufficiently modern date to belong to the era when man was contemporary with the Mammoth and Rhinoceros in the basin of the Meuse (Antiquity of Man, p. 77). We still have exhalations of carbonic acid and calcareous springs in this district, which are the dying embers of the old fires so recently in activity.

If we go further east, we find the chief areas where the European Loess is distributed, Hungary, Moravia, the Carpathians and Transylvania, strewn with relics of volcanic energy, basaltic, trachytic, and tufaceous deposits abounding. Many of these are of late geological date. Many admittedly of as late as Tertiary times. I believe that the volcanic energy of this vast congeries of confused mountains lasted until much later times, and we still have in Transylvania and Wallachia mud volcanos in activity; while in the former country the volcanos of Budos Hegy still emit large quantities of gas and vapour. If we turn to the Chinese Loess, we shall find that it also is focussed about, and is in immediate contact with a district in which volcanic action has been active down to quite a recent historical period. Mr. Pumpelly has described the border districts of China and Mongolia in a well-known paper in the 15th volume of the Smithsonian Contributions to Knowledge, and speaks at some length in reference to the volcanic strata of Southern Mongolia. Speaking of the Shamo Desert and its borders, he says: "The volcanic rocks of Lake Baikal and of the region to the east, the occurrence of products of this class in place and as scattered fragments at many points on the route across the plateau, and finally the information derived from Chinese authorities concerning the existence within historical times of active volcanos, among the mountains of Manchuria to the east and in the Tien-shan of the west, all point to a development of volcanic activity, which was formerly coextensive with the area of the present table-land. The remains of this action make themselves felt in the violent earthquakes that from time to time shake the districts of Northern Chihli and the shores of Lake Baikal" (*op. cit.* pp. 75, 76). The mountains that border the Mongolian desert on the south are full of traces of recent volcanic action, and seem as closely connected with and to be as much the focus of the distribution of the Loess as those of Central Europe. This clue, in the absence of others, is assuredly worth prosecuting. Can it be that the Loess, which we have seen many reasons to doubt having been of either subaqueous or subaerial origin, may be of subterranean origin? This somewhat paradoxical proposition may not seem so extravagant when examined a little more closely.

Mr. Steininger and Dr. Hibbert-Ware have shown that the Rhine volcanos, when active, poured out an immense quantity of mud, which has been consolidated into tufa; and the latter expressly compares them to the mud volcanos or moyas of the Western World described by Humboldt. This mud is formed from the volcanic sand or ash, which is itself the product of the destruction of the subjacent strata, and whose chief characteristic is its extremely comminuted character and minute state of mechanical division (which is one of the peculiar features of the particles which form the Loess itself). This state of minute division, as Dr. Hibbert-Ware says, makes it easy to form a paste out of the dust when it is mixed with water. He attributes the formation of the various tufas which occur in the district which he describes "to the boiling tufaceous mud, or moya, which once filled, even to an overflow, the valley of Rieden" (*op. cit.* p. 40). The occurrence of this mud in various districts of the Rhine volcanic area is pointed out in many passages by Dr. Hibbert-Ware. Its density and composition differ with the materials out of which it has been formed, and the character of the adjacent rocks, and in some cases has been considerably altered. Thus, Dr. Ware describes how, by the action of water, "the substance of the tufaceous mud would be so intimately blended with the fine sand and plastic clay (as at Neuwied) as to assume a less firm consistency, which at the present day is indicated by the rapidity with which the mixed deposit is disintegrated; particularly by the action of rains. But although the tufa is thus disguised, its origin, after a little experience, may be easily recognized, owing to the yellow or brownish colour and pulverulent, yet harsh feel, which it continues to preserve" (Hibbert-Ware, *op. cit.* p. 43).

Again, speaking of the tuff on the flanks of the Veitskopf, he says: "It is perhaps in the present instance less mixed with sand but more with fine clay, and hence its brighter yellow tint, its more pulverulent and earthy aspect, and its still more friable and loose consistence" (*id.* p. 50). The consistency and internal structure and composition of the tufaceous mud depends in fact on the materials out of which it was formed. If the rocks, instead of, as at Neuweid, being of Palæozoic age, and consisting mainly of clay-slates, etc., were partially limestones, we should doubtless have a mud formed from them containing large quantities of carbonate of lime. Not only have we such rocks in the Rhine Valley, which are the natural matrix from which one ingredient of the Loess might be derived, but we have numerous calcareous springs forming travertine at this very moment, and also have exhalations of carbonic acid, showing the kind of material that exists below the surface. I would venture, therefore, upon the theory that the Loess is in the main a volcanic mud. The comminuted character of its ingredients, the way in which it is highly charged with carbonates, and its distribution mantling a recently active volcanic district—are positive elements in its favour; while the impossibility apparently of explaining the origin of the deposit in any other way, and the absence so far as we can judge of any objections to it on other grounds, are negative factors also in its favour. I do not say that the Loess exactly as we find it was protruded from the fissures or volcanic vents whence it came. As we shall see, it has been very largely steeped in floods of water, and has doubtless also been much mixed with the ingredients of the superficial bed over which it poured. But, in the main, I believe the most reasonable explanation of the difficulties that surround it to be, that it is a disintegrated volcanic mud, standing in the same relation to tufa that the Post-Glacial sandstones of the Rhine Valley, which have been consolidated and cemented by carbonate of lime and iron, do to the loose sands of the same area dating from the same period. Just as the Loess occurs in great unstratified masses, so does the tufa on the Rhine—a fact which is repeatedly mentioned by Dr. Ware, who makes it the subject-matter of an important inference in the following sentence: "The proof that this overflow of moya was *a very sudden one* is shown in the total, or nearly total, absence of all marks of stratification" (*op. cit.* p. 45). There have also occurred in these tufaceous deposits debris of vegetation, etc., resembling those in the travertines of Bruhl, whose contemporaneity to the Loess deposits is hardly questionable. On every ground known to me the probability seems overwhelming that the Loess was in fact caused by a vast outpouring of subterranean mud.

The following notice of a modern outburst of such mud is not a bad illustration of what probably occurred on a much larger scale here.

Near "St. Lucedo," says Lyell, "among other places, the soil is described as having been dissolved, so that large torrents of mud inundated all the low grounds, like lava. Just emerging from this mud the tops only of trees and of the ruins of farm-houses were seen. Two miles from Laureana, the swampy soil in *two ravines became filled with calcareous matter, which oozed out from the ground immediately before the first great shock.* This mud rapidly accumulating, began ere long to roll onward, like a flood of lava, into the valley, where the two streams uniting, moved forward with increased impetus from east to west. It now presented a breadth of 225 feet by 15 in depth, and before it ceased to move covered a surface equal in length to an Italian mile. *In its progress it overwhelmed a flock of 30 goats, and tore up by the roots many olive and mulberry trees, which floated like ships upon its surface*" (Lyell's Principles of Geology, vol. ii. p. 133).

The theory receives support in another way. Hardly less puzzling than the Loess, in fact more so, is the vast deposit of black earth which occurs in Central Russia, and which is known as Tschernozom or black earth. It has exercised the ingenuity of various inquirers, and still demands an explanation. Its northern limit, according to Murchison, may be defined by a wavy line passing from near Kief and Tchernizof, a little to the south of Lichvin. It appears in 54° N.L. in that tract, and advances in its course eastwards to 57°, and occupies the left bank of the Volga west of Tchekboksar, between Nijni Novgorod and Kazan. Murchison saw none of it north of Kazan, but plenty of it on the Kama and the Ufa. On the Siberian side of the Urals he passed through a large mass of it near Kamensk, south of the river Isoetz, in latitude 56° north, and through another between Miask and Troitsk, and he was given to understand that it spreads over considerable spaces in the eastern, central, and southern parts of the great Siberian plains. He met with it occasionally in the low gorges of the Urals, and in the Bashkir country on both flanks of the Southern Ural (in plateaux more than 1000 feet above the sea), and also in the Kirghiz Steppes.

The distribution of the black earth is singularly like that of the Loess, its texture is like that of the Loess in being comminuted and fine, especially the siliceous part of it. Like the Loess, it is found at all levels in European Russia, sometimes on plateaux 400 feet above the valleys, in other places on undulations, and often in broad valleys where the rivers having cut through the deposit expose its thickness. It is like the Loess in being unstratified, and in being everywhere homogeneous. Its position relative to the drift and river gravels is that of the Loess, for, except at one spot, near Voroney, mentioned by Murchison, it overlaps the drift, and is subsequent to it. In every respect, save its dark colour and the material of which it is composed and in its contents, it is the exact counterpart of the Loess. Schmidt identifies the black earth of Russia with the Loess, and says it is substantively nothing but Loess (Letter to Richthofen, Zeits. Deutsch. Geol. Ges. vol. xxix. pp. 830-1). Mr. Geikie says of it that it occupies the same geological horizon as the Loess, and that its origin is undoubtedly closely bound up with it (*op. cit.* p. 157). Like the Loess, it is distributed about an apparently recently disturbed mountain focus, namely, the Southern Urals. What are we to say then about the origin of the black earth? Here, at all events, there is no room for glacial action, for the most conspicuously glaciated district in Russia, namely, its northern part, is quite free from black earth. Nor, so far as we know, is there any evidence that the low range of the Southern Urals was once occupied by glaciers. M. d'Archiac says, there are no traces of glacial action in the Urals (Leçons sur la Faune Quaternaire, p. 168). Nor, again, do we know of glacial mud anywhere like the Russian Tschernozom. At first sight, its black colour would suggest that it was merely a vast deposit of vegetable soil.

Murchison and others have shown good reasons against attributing it to the decay of vegetable matter. Thus speaking of its uniformity Mr. Strangeways says: "It is difficult to imagine that the same plants ever grew in so many situations with such opposite aspects, on such different soils, and over so vast a surface." This view is indorsed by Murchison, who says, that nowhere does it contain a trace of trees, roots, or vegetable fibre. Again, as he says, "if the Tschernozom had been due to the decay of trees, it would have been found largely in North Russia, where forests have so long existed. But nowhere in North Russia has it occurred, while it especially abounds in those wide steppe-like undulations which have in all time been void of trees" (Russia and the Ural Mountains, pp. 557–561). Having discarded this subaerial origin, we may add, that the fact that it contains not a trace of a marine or freshwater organism of any kind precludes our assigning it to a marine, lacustrine or fluviatile origin. What then remains to explain this curiously distributed mantle of black earth, but the pouring out of a great mass of volcanic mud from some fissures or vents contemporaneously with the similar pouring out of the Loess? As the Loess was probably derived from the volcanic disintegration of calcareous rocks, so the black earth was probably, as Murchison has suggested, due to the disintegration of the black Jurassic shale which he describes as so uniform in colour over all Northern and Central Russia, and which view is confirmed by the absence of the black earth to the south of certain tracts where the Jurassic shales have apparently never occurred.

It is confirmed again by the analyses which have been made of it, in which we find a certain proportion of organic matter, which such a high authority as Bischoff attributes to the large amount of bituminous matter contained in the Jurassic shale (see Geikie, *op. cit.* pp. 242–3.) This view of the origin of the black earth admirably suits the absence from it of stratification and of organic remains; for these latter, when found in the Loess, were probably, as we shall presently show, derived from elsewhere. The view we would urge, then, is, that the great dislocations of strata which occurred at the time when the Mammoth and his companions disappeared, were accompanied by the pouring out of a great quantity of volcanic mud, which in Europe and China is largely represented by the Loess, while in Central Russia it is represented by the black earth.

Having decided the origin of the Loess and black earth, we have by no means solved all, or the main difficulty connected with these paradoxical deposits. We have merely laid down the basis for the real contention of this paper—namely, that a large part of the Loess and Tchernozom are not *in situ*, but have been transported and redeposited. This conclusion seems inevitable, if we consider certain critical facts.

The pouring out of volcanic mud would doubtless fill up and choke the valleys in which the outburst took place, or the immediate vicinity of the place, but it could not explain by itself the distribution of the ejected matter in a continuous mantle spread over valley and hill irrespective of the drainage of the country. The upland Loess spread so uniformly as it is in many places could only have been brought there by some potent moving power. The extent to which the Loess is found on the plateaux is really surprising. Mr. Geikie says that in Moravia it is found at a height of 1300 feet, while it stretches into the valleys of the Carpathians up to heights of 800 and 2000 feet. In some cases even higher, namely, to 3000 feet, according to Zeuschner, and to 4000 or 5000 feet according to Korzistka (Prehistoric Europe, p. 146). Again, he says, "It must not be supposed that the Loess is restricted to valleys and depressions in the surface of the ground. It is true that it attains in these its greatest thickness, but extensive accumulations may often be followed far into the intermediate hilly districts, and over the neighbouring plateaux. Thus the Odenwald, the Taunus, the Vogelgebirge, and other upland tracts, are cloaked with Loess up to a considerable height" (*id.*). Mr. Belt tells us that in the valleys of the Rhine, the Danube, and their tributaries, the Loess is found to a great height above the present rivers. Near Basle he traced it to the top of the hill, or a height of 1470 feet above the sea, and 660 above the river. It covers the well-known volcanic hill situated in the middle of the Rhine Valley, known as the Kaizerstuhl, to a height of 1600 feet above the sea, and is also spread over the volcanic hills of the Lower Eifel. Von Dechen found it north of Andernach, near the hill of Korrets, at a height of 620 feet; and Dr. Hibbert seems to have found it higher, for he states that on the Mahlsberg it attains an elevation of 800 feet above the sea, and 600 feet above the river, *and is sometimes* 60 *feet thick* (Belt, Quart. Journ. of Science, N.S. vol. vii. p. 70). Speaking of the neighbourhood of Blosenberg, the same writer says, "On the hill-tops it occurs to 1100 feet or more, and Dr. Sandberger informed me that it *is sometimes thick on the hill-tops*, and contains the characteristic Loess shells, though not so abundantly as lower down the valley" (*id.* p. 72). He tells us again that "the Loess is found up to a height of 1300 feet above the sea in the upper part of the Danube Valley, and that the low hills bounding the valley, near Krems, are all covered with Loess, and sections are exposed showing a thickness of 60 feet without its base being seen" (*id.*). In France, as M. d'Archiac says, it is found on high plateaux 600 feet above some of the rivers, such as the Marne; while in Belgium it caps some of the highest hills or table-land around Brussels at the height of 300 feet above the sea (Lyell's Antiquity of Man, pp. 377–379). Credner tells us that on the slopes of the valleys of the Oder and the Vistula it is found to a height of 400 mètres above the sea-level (Credner, *op. cit.* p. 669). Jentsch speaks of it as covering the plateaux about the Elbe. Between Briesswitz and Lentewitz it is found at 400–450 feet above the sea, while at Nothinz it occurs as high as 770 feet above the sea-level (*op. cit.* p. 39). But it is in China that the high-level Loess is so predominant. There it overspreads hills and valleys alike, and Mr. Kingsmill tells us that in Shansi and Mongolia it occurs at a height of 6000 feet, and in a deposit of the depth of 1000 feet. In the southern limits of the Chinese Loess in Kiang-su, he says it does not at present rise to more than 200 feet, though apparent fragments on the sides of the hills rise possibly to 400 feet (Journ. Geol. Soc. vol. xxvii. p. 382). These facts are very suggestive. It is incredible that subaerial deposits should have been deposited at a height of 6000 feet, and to the depth of 1000 feet, as it is incredible that such deposits should have been accumulated in a mantle of many feet over the high ground where the Loess is now so abundant. There is only one conclusion possible, namely, that the upland Loess is not *in situ*, that it has been largely transported to where it is now found. The question that suggests itself therefore is, what was the transporting power? Following the analogy of snow-drifts, which, when first the snow falls, are arranged in a continuous mantle, and are afterwards heaped up in certain favourable localities by the wind, Baron Richthofen suggested that the wind was a prime element in the distribution of the Loess, and that the deposit largely consists of the fine dust of the Shamo Desert, acted upon by north winds blowing for untold ages. This view is surely not tenable. Père David and Mr. Kingsmill have both reasonably objected to it, but have not stated the most cogent reasons. The first is, that it treats the problem as a local Chinese problem, while it ignores that the Loess has to be accounted for in Europe as well as in China; and here we have no Shamo Desert or other sources whence storm winds could bring the fine calcareous sand. Secondly, the blowing of such winds continuously, argues a very dry climate, while the land-shells in the Loess argue just the reverse. Thirdly, the theory ignores the contents of the Loess. How could the shells and the animal debris be carried by the wind? If the former were rolled along by a hurricane for a few hundreds of miles, they would become broken and weathered, and not be fresh as they are now. But even a hurricane would be inadequate to move the remains of Mammoths and Rhinoceroses for such a distance. Fourthly, wind acting on sand would form great ranges of dunes along the northern frontiers of China; but this is not the mode of occurrence of the Loess. Lastly, the cause assigned by Baron Richthofen would merely account for the transfer of the Loess from Mongolia to China, and not, as he supposes, explain the origin of the Loess itself. As Mr. Kingsmill says, unless the winds passed over the Loess itself, it is difficult to see whence they could obtain the necessary ingredients. Clay would not be acted on by wind; sand of itself would not suffice to form the peculiar mixture of ingredients; limestone cannot be disintegrated by the atmosphere so as to be reduced to dust capable of being transported in the manner suggested. The means are quite inadequate to the end (Kingsmill, *op. cit.* p. 381). We have therefore to look elsewhere.

How would the postulate of a deluge on a large scale enable us to clear up the difficulties in the distribution of the Loess? If it would explain them all, are we not driven to accept it? Let us see then how the case stands. Such a flood of waters rushing over a district in which the Loess was being poured out would in fact take it up as it sped along and distribute it independently of the drainage over plateaux and valleys in a continuous mantle or sheet. It would in the second place pile it up in drifts wherever the water met with resistance or ceased to flow rapidly, thus accounting for the immense deposits which occur in special localities, as in the Loess near Wurzburg, described by Mr. Belt, of which he expressly says: "It has been principally preserved, from the effects of great floods that appear to have swept down the valleys, in bays and recesses, and at these points bones of the Mammoth and its associates have been found." In the third place it would account for the Loess being of a homogeneous character independently of the subjacent strata—a fact which has been mentioned by Père David in China, and would account also for its being distributed so often over beds of gravel in Germany, where we cannot suppose it was the result of the denudation of the surface immediately below. In the fourth place, it would account for the absence of stratification in the Loess, for stratification is due to a deposit being made in successive layers by a series of depositions; while, in this case, it would be deposited in one continuous mass. Fifthly, it would account for the Loess occurring in the heads of the tributary valleys of the big continental rivers and in those running up into the Carpathians, where it is found choking the heads of the valleys and ravines as if thrust up into them by an impelling force from behind. Sixthly, it would account for the greater part of the heavier materials, such as bones, etc., the wave of water and mud met with on its progress, being left in the valleys, while the lighter, such as the shells, were carried along to the upper ground; it being a well-known characteristic of the Loess, as of the contemporary diluvium of the French writers, that when it occurs on the plateaux, it is almost free from animal remains, etc. Dr. Hibbert-Ware, whose main theory of the origin of the Loess I cannot accept, shows very clearly that it has been subject to very considerable redistribution. Take the following example, for instance. Speaking of the Loess near Strassburg, he says: "The lowest beds of some small hills, or knolls of transported Loess which had been deposited, appear to have included the heavier particles, consisting of sand, in which appear rolled pebbles distributed in the form of veins. In a higher bed, the sand which has thus subsided is varied by the presence of removed masses of Loess, as well as by land and fluviatile shells, and even by the bones of Mammalia which it seems to have entangled in its course. But the uppermost bed is distinguished by the usual character of Loess, which here displays itself of a yellow colour, and of a very friable consistence, in which are entangled shells and bones of animals. It is also perfectly unstratified. . . . . Such is the general order of subsidence which the Loess in its breaking up, in its removal, and in its subsequent deposition, appears to have observed" (*op. cit.* p. 197-8). What Dr. Hibbert-Ware says here of the irregular arrangement and dislocation of the beds of Loess in several cases can be confirmed from other writers. Pockets and seams of sand and gravel, evidently false-bedded, occur in it, as it is attested by several writers. Thus, Mr. Belt says of the Loess at Krems, "that it contains patches and seams of gravel, and pebbles of quartz are irregularly scattered throughout it. That it is unstratified, but occasionally lines of division are seen separating portions of slightly different colour and composition" (*op. cit.* p. 73). At Blosenberg the same writer noticed that the Loess was divided into two beds by a clear line of division, the upper one being of a lighter colour than the lower (*id.* p. 71).

Again, as Mr. Geikie urges, "the presence of lines of gravel and sand (in the Loess), which here and there have been observed, indicates unquestionably the action of water; and the same may be said of such alternations as those described by Dr. Nehring, which occur at Thiede and Westeregeln, and of the bedded Loess of Heiligenstadt near Vienna, referred to by Dr. Jentzsch. Again, at Nussdorf and Hungelbrunn, in the same region, the Loess, according to M. Fuchs, contains freshwater shells *in a distinct bed.*"

The black earth also shows signs that it has been largely transported by some wide-spread wave of waters. Its occurrence on plateaux and valleys alike irrespective of the drainage of the country over so wide an area and so uniformly constituted; and Murchison urges in fact that it has been redistributed "by the powerful currents which carried southwards so many debris of the drift of which it was doubtless once the covering mantle in many places now bare of it."

Mr. Geikie, with whose general conclusion I cannot agree, is here at one with me. "The black earth," he says, "would appear never to reach the great thickness attained by the Loess of the Rhine and the Danube. This is what we might have expected from the configuration and position of the regions over which it is distributed. *The wide open valleys and broad plateaux would not permit of the same heaping up and pounding back of the flood waters as must have taken place again and again in Central Europe.* The route to the south lay open, and the inundation waters would thus be drawn off more rapidly than if they had been discharged in a northerly direction," etc. Mr. Geikie goes on to argue that the Northern outlet was blocked with ice, involving the contemporaneity of the Loess deposits with glacial conditions, which seems at issue with the great mass of evidence; but the fact of the flood and its effects I cordially accept.

ve turn from the stratigraphical considerations to the palæonto-
l ones, we shall have the same consistent story to tell. The
rence of skeletons of Mammals in the Loess of Germany as we
described, and of huge deposits or caches as at Cannstadt, show
he conditions of their deposit were the same as those in Siberia.
animals had died naturally, their remains would have decayed
on the surface and been weathered and scattered. The only
tion on which the bones could be preserved in skeletons is that
must have been covered up soon after death not with a super-
layer of mud, but with a substantial covering, and this could
be by the Loess having been swept over the bones in large
ities by some diluvial movement. As a matter of fact, these
are always found buried in the Loess, and not on its surface.
e wave of water and of mud in sweeping along would no doubt
a considerable denuding influence upon the beds of sand and
which underlie the Loess in many places, and which, in my
are the exact and corresponding equivalents of the diluvium of
rench writers, and which I take to be the remains of the old
surface on which the Mammoth lived. It would take up a con-
able quantity of the contents of this surface deposit and incor-
e it with itself. Thus it comes about that some of the bones
l in the Loess are much decomposed, "which, says Dr. Hibbert-
, creates a suspicion that this might have been their state before
became entangled in the Loess" (*op. cit.* p. 203). The
tons of man and the other animals, the great hecatombs of
, and the debris of dicotyledonous plants, etc.;—these no doubt
sent the actual living inhabitants of the district where the great
low of waters took place, and were destroyed by one over-
ming blow. We have singular cases on a smaller scale with
h to compare what must in fact have happened. Thus, a
us eruption of mud took place from one of the volcanos
va in 1822. Of the effects of this eruption Lyell says: "A
of twenty-four miles between the mountains and the River
loi was covered to such a depth with bluish mud that people
buried in their houses, and not a trace of the numerous villages
lantations throughout that extent was visible. *Within this space*
*odies of those who perished were buried in mud and concealed, but*
*the limits of the volcanic action they were exposed and strewn over*
*round in great numbers, partly boiled and partly burnt.* . . . .
day after the eruption the rain fell in torrents, and the rivers,
ly charged with mud, deluged the country far and wide. . . .
first intimation the inhabitants of Bandory received of this
ity was the news that the River Wulna *was bearing down into*
*a the dead bodies of men, and the carcases of stags, rhinoceroses,*
, *and other animals*" (Lyell's Principles vol. ii. p. 58). This
ely a very graphic parallel to what must have taken place on a
scale when the Mammoth perished finally. In conclusion,
pose to quote a passage in support of my main contention from
vith whom I differ greatly in other respects.

us, Mr. Belt is at one with me in regard to the critical fact that the Loess presents traces everywhere of a great diluvial movement. I cannot follow him in attributing it to the Glacial period, and to the bursting of a huge barrier of ice letting loose the waters of a great inland lake. All this seems to me to be at issue with the evidence, but I must claim what he says as to a great debacle, as, in fact, a proof of my position as a Post-Glacial flood. Of this debacle he says: "It is to the first rising of the waters that I attribute the destruction of the Mammoth and the Woolly Rhinoceros, and probably of Palæolithic man in Europe. The evidence is perhaps not so conclusive with regard to Palæolithic man, but as concerns the two great quadrupeds it is clear and decisive. I can find nowhere in Europe a trace of their existence after the first rise of the waters. In the great debacle their bones were carried and spread out over the low grounds along with the lowland gravel, and, doubtless, often carried into the top of low-lying patches of Boulder-clay, but in these cases they are broken, single, or rolled" (Belt, *op. cit.* p. 89).

Sporadic inundations and floods are also postulated over and over again in the pages of Mr. Geikie as periodical effects of the melting of ice, etc.; but the fact is, if we are to find a cause which operated uniformly from the Yellow Sea to the Atlantic, and left no traces of intermittent action great or small, but uniform unstratified mantles of deposit, marking one substantive and supreme cause, we must forego these local and fragmentary predicates, and postulate one overwhelming flood, such as is demanded by the evidence we have collected from other sources. I propose, in another paper, to deal with the so-called Diluvium of the French and Russian writers, and its correlated deposits.

*Note.*—I would add from Mr. Belt's paper, another example of the occurrence of *a skeleton* of what was doubtless a Mammoth to those already cited in a former paper. He says, "It is related that when, in the Thirty Years' War, the Swedes were besieging Krems, they found in one of their trenches the skeleton of a monstrous animal, and that besiegers and besieged ceased from their warfare for a time to gaze on the huge teeth of the giant that had been dug up" (*op. cit.* p. 73).

## NOTICES OF MEMOIRS.

### CLASSIFICATION OF THE DINOSAURIA. By Prof. O. C. MARSH, M.A., F.G.S.[1]

IN the May number of the American Journal of Science (p. 423), I presented an outline of a classification of the Jurassic Dinosaurian Reptiles of this country which I had personally examined. The series then investigated is deposited in the Museum of Yale College, and consists of several hundred individuals, many of them well preserved, and representing numerous genera and species. To ascertain how far the classification proposed would apply to the material gathered from wider fields, I have since examined various

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[1] Read before the National Academy of Sciences, at the Philadelphia meeting, November 14, 1881.

Dinosaurian remains from other formations of this country, and likewise, during the past summer, have visited most of the museums of Europe that contain important specimens of this group. Although the investigation is not yet completed, I have thought the results already attained of sufficient interest to present to the Academy at this time.

In previous classifications, which were based upon very limited material compared with what is now available, the Dinosaurs were very generally regarded as an order. Various characters were assigned to the group by Von Meyer, who applied to it the term *Pachypoda*; by Owen, who subsequently gave the name *Dinosauria*, now in general use; and also by Huxley, who more recently proposed the name *Ornithoscelida*, and who first appreciated the great importance of the group, and the close relation it bears to Birds. The researches of Leidy and Cope in this country, and Hulke, Seeley, and others in Europe, have likewise added much to our knowledge of the subject.

An examination of any considerable portion of the Dinosaurian remains now known will make it evident to any one familiar with reptiles, recent or extinct, that this group should be regarded, not as an order, but as a sub-class, and this rank is given it in the present communication. The great number of subordinate divisions in the group, and the remarkable diversity among those already discovered, indicate that many new forms will yet be found. Even among those now known, there is a much greater difference in size and in osseous structure than in any other sub-class of vertebrates, with the single exception of the placental Mammals. Compared with the Marsupials, living and extinct, the *Dinosauria* show an equal diversity of structure, and variations in size from by far the largest land animals known—fifty or sixty feet long—down to some of the smallest, a few inches only in length.

According to present evidence, the Dinosaurs were confined entirely to the Mesozoic age. They were abundant in the Triassic, culminated in the Jurassic, and continued in diminishing numbers to the end of the Cretaceous period, when they became extinct. The great variety of forms that flourished in the Triassic render it more than probable that some members of the group existed in the Permian period, and their remains may be brought to light at any time.

The Triassic Dinosaurs, although so very numerous, are known to-day mainly from footprints and fragmentary osseous remains. Not more than half a dozen skeletons, at all complete, have been secured from deposits of this period; hence, many of the remains described cannot at present be referred to their appropriate divisions in the group.

From the Jurassic period, however, during which Dinosaurian reptiles reached their zenith in size and numbers, representatives of no less than four well-marked orders are now so well known that different families and genera can be very accurately determined, and almost the entire osseous structure of typical examples, at least, be made out with certainty. The main difficulty at present with the

Jurassic Dinosaurs is in ascertaining the affinities of the diminutive forms which appear to approach Birds so closely. These forms were not rare, but their remains hitherto found are mostly fragmentary, and can with difficulty be distinguished from those of Birds, which occur in the same beds. Future discoveries will, without doubt, throw much light upon this point.

Comparatively little is yet known of Cretaceous Dinosaurs, although many have been described from incomplete specimens. All of these appear to have been of large size, but much inferior in this respect to the gigantic forms of the previous period. The remains best preserved show that, before extinction, some members of the group became quite highly specialized.

Regarding the Dinosaurs as a sub-class of the Reptilia, the forms best known at present may be classified as follows:—

### Sub-Class DINOSAURIA.

Premaxillary bones separate; upper and lower temporal arches; rami of lower jaw united in front by cartilage only; no teeth on palate. Neural arches of vertebræ united to centra by suture; cervical vertebræ numerous; sacral vertebræ coössified. Cervical ribs united to vertebræ by suture or ankylosis; thoracic ribs double-headed. Pelvic bones separate from each other, and from sacrum; ilium prolonged in front of acetabulum; acetabulum formed in part by pubis; ischia meet distally on median line. Fore and hind limbs present, the latter ambulatory and larger than those in front; head of femur at right angles to condyles; tibia with procnemial crest; fibula complete. First row of tarsals composed of astragalus and calcaneum only, which together form the upper portion of ankle joint.

### (1.) Order Sauropoda (Lizard foot). Herbivorous.

Feet plantigrade, ungulate; five digits in manus and pes; second row of carpals and tarsals unossified. Pubes projecting in front, and united distally by cartilage; no post-pubis. Precaudal vertebræ hollow. Fore and hind limbs nearly equal; limb bones solid. Sternal bones parial. Premaxillaries with teeth.

(1) Family *Atlantosauridæ.* Anterior vertebræ opisthocœlian. Ischia directed downward, with extremities meeting on median line.

Genera *Atlantosaurus, Apatosaurus, Brontosaurus, Diplodocus, ? Camarasaurus (Amphicœlias), ? Dystrophæus.*

(2) Family *Morosauridæ.* Anterior vertebræ opisthocœlian. Ischia directed backward, with sides meeting on median line.

Genus *Morosaurus.*

European forms of this order: *Bothriospondylus, Cetiosaurus, Chondrosteosaurus, Eucamerotus, Ornithopsis, Pelorosaurus.*

### (2.) Order Stegosauria (Plated lizard). Herbivorous.

Feet plantigrade, ungulate; five digits in manus and pes; second row of carpals unossified. Pubes projecting free in front; post-pubis present. Fore limbs very small; locomotion mainly on hind limbs. Vertebræ and limb bones solid. Osseous dermal armour.

(1) Family *Stegosauridæ.* Vertebræ biconcave. Neural canal in sacrum expanded into large chamber; ischia directed backward, with sides meeting on median line. Astragalus coössified with tibia; metapodials very short.

Genera *Stegosaurus* (*Hypsirhophus*), *Diracodon*, and in Europe, *Omosaurus*, Owen.

(2) Family *Scelidosauridæ.* Astragalus not coössified with tibia; metatarsals elongated; four functional digits in pes. Known forms all European.

Genera *Scelidosaurus*, *Acanthopholis*, *Cratæomus*, *Hylæosaurus*, *Polacanthus.*

(3.) Order ORNITHOPODA (Bird foot). Herbivorous.

Feet digitigrade, five functional digits in manus and three in pes. Pubes projecting free in front; post-pubis present. Vertebræ solid. Fore limbs small; limb bones hollow. Premaxillaries edentulous in front.

(1) Family *Camptonotidæ.* Clavicles wanting; post-pubis complete.

Genera *Camptonotus*, *Laosaurus*, *Nanosaurus*, and in Europe *Hypsilophodon.*

(2) Family *Iguanodontidæ.* Clavicles present; post-pubis incomplete. Premaxillaries edentulous. Known forms all European.

Genera *Iguanodon*, *Vectisaurus.*

(3) Family *Hadrosauridæ.* Teeth in several rows, forming with use a tessellated grinding surface. Anterior vertebræ opisthocœlian.

Genera *Hadrosaurus*, ? *Agathaumas*, *Cionodon.*

(4.) Order THEROPODA (Beast foot). Carnivorous.

Feet digitigrade; digits with prehensile claws. Pubes projecting downward, and coössified distally. Vertebræ more or less cavernous. Fore limbs very small; limb bones hollow. Premaxillaries with teeth.

(1) Family *Megalosauridæ.* Vertebræ biconcave. Pubes slender, and united distally. Astragalus with ascending process. Five digits in manus and four in pes.

Genera *Megalosaurus* (*Poikilopleuron*), from Europe. *Allosaurus*, *Cœlosaurus*, *Creosaurus*, *Dryptosaurus* (*Lælaps*).

(2) Family *Zanclodontidæ.* Vertebræ biconcave. Pubes broad elongate plates, with anterior margins united. Astragalus without ascending process; five digits in manus and pes. Known forms European.

Genera *Zanclodon*, ? *Teratosaurus.*

(3) Family *Amphisauridæ.* Vertebræ biconcave. Pubes rod-like; five digits in manus and three in pes.

Genera *Amphisaurus* (*Megadactylus*), ? *Bathygnathus*, ? *Clepsysaurus*; and in Europe, *Palæosaurus*, *Thecodontosaurus.*

(4) Family *Labrosauridæ.* Anterior vertebræ strongly opisthocœlian, and cavernous. Metatarsals much elongated. Pubes slender, with anterior margins united.

Genus *Labrosaurus.*

### Sub-Order Cœluria (Hollow tail).

(5) Family *Cœluridæ.* Bones of skeleton pneumatic or hollow. Anterior cervical vertebræ opisthocœlian, remainder biconcave. Metatarsals very long and slender.

Genus *Cœlurus.*

### Sub-Order Compsognatha.

(6) Family *Compsognathidæ.*—Anterior vertebræ opisthocœlian. Three functional digits in manus and pes. Ischia with long symphysis on median line. Only known specimen European.

Genus *Compsognathus.*

## DINOSAURIA?

### (5.) Order Hallopoda (Leaping foot). Carnivorous?

Feet digitigrade, unguiculate; three digits in pes; metatarsals greatly elongated; calcaneum much produced backward. Fore limbs very small. Vertebræ and limb bones hollow. Vertebræ biconcave.

Family *Hallopodidæ.*

Genus *Hallopus.*

The five orders defined above, which I had previously established for the reception of the American Jurassic Dinosaurs, appear to be all natural groups, well marked in general from each other. The European Dinosaurs from deposits of corresponding age fall readily into the same divisions, and, in some cases, admirably supplement the series indicated by the American forms. The more important remains from other formations in this country and in Europe, so far as their characters have been made out, may likewise be referred with tolerable certainty to the same orders.

The three orders of Herbivorous Dinosaurs, although widely different in their typical forms, show, as might be expected, indications of approximation in some of their aberrant genera. The *Sauropoda,* for example, with *Atlantosaurus* and *Brontosaurus,* of gigantic size, for their most characteristic members, have in *Morosaurus* a branch leading toward the *Stegosauria.* The latter order, likewise, although its type genus is in many respects the most strongly marked division of the Dinosaurs, has in *Scelidosaurus* a form with some features pointing strongly towards the *Ornithopoda.*

The Carnivorous *Dinosauria* now best known may all be placed at present in a single order, and this is widely separated from those that include the herbivorous forms. The two sub-orders defined include very aberrant forms, which show many points of resemblance to Mesozoic Birds. Among the more fragmentary remains belonging to this order, but not included in the present classification, this resemblance appears to be carried much farther.

The order *Hallopoda,* which I have here referred to the *Dinosauria,* with doubt, differs from all the known members of that group in having the hind feet especially adapted for leaping, the metatarsals being half as long as the tibia, and the calcaneum produced far backward. This difference in the tarsus, however, is not greater than may be found in a single order of Mammals, and is no more than might be expected in a sub-class of Reptiles.

Among the families included in the present classification, I have retained three named by Huxley (*Scelidosauridæ, Iguanodontidæ*, and *Megalosauridæ*),[1] although their limits as here defined are somewhat different from those first given. The sub-order *Compsognatha*, also, was established by that author in the same memoir, which contains all the more important facts then known in regard to the *Dinosauria*. With the exception of the *Hadrosauridæ*, named by Cope, the other families above described were established by the writer.

The *Amphisauridæ* and the *Zanclodontidæ*, the most generalized families of the *Dinosauria*, are only known from the Trias. The genus *Dystrophæus*, referred provisionally to the *Sauropoda*, is likewise from deposits of that age. The typical genera, however, of all the orders and sub-orders are Jurassic forms, and on these especially the present classification is based. The *Hadrosauridæ* are the only family confined to the Cretaceous. Above this formation there appears to be at present no satisfactory evidence of the existence of any *Dinosauria*.

## REVIEWS.

### I.—The Water Supply of England and Wales. By Charles E. De Rance, Assoc. Inst. C.E., F.G.S., etc. Royal 8vo. pp. 623; 6 Coloured Maps. (London: Edward Stanford, 1882.)

THE necessity of a ready and easily accessible water supply has been probably the most common cause (although other causes may have sometimes operated) in determining the sites of habitations, villages, and towns in former times.

Professor Prestwich has shown that the early growth of London followed unerringly the water-bearing gravel (from 10 to 20 feet in thickness) of the Thames Valley, eastwards towards Bow, Whitechapel, and Stepney; north-eastwards towards Clapton, Hackney, and Newington, and westwards towards Kensington and Chelsea; while northward it came for many years to a sudden termination where this bed of gravel ends abruptly and the London Clay comes to the surface, and occupies all the ground to the north. On the outskirts of London, a succession of villages grew up on the great beds of gravel ranging on the east, on the north along the Lea Valley, on the west, and on the south of the Thames, while the old habitations of Hampstead and Highgate are due to the water-bearing Bagshot Sands which cap these elevations; again, where the permeable gravel of the Boulder-clay series covers the London Clay hills to the north, we have the old settlements of Hendon, Finchley, Barnet, and other villages. (Ann. Address Geol. Soc. 1872, pp. 29–31.)

The extension of Metropolitan London upon an increased water supply is clearly indicated by the coloured Map given by Mr. De Rance (p. 179), showing the areas built upon at different dates from

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[1] Quart. Journ. Geol. Society of London, vol. xxvi. p. 34, 1870.

Old London in 1560, and successively in 1745, 1818–34–67, to the present time 1881, which is further supplemented by another Map (p. 184), on which the areas now supplied by the nine different water companies are fully shown.

Mr. Topley has pointed out the relation of the parish boundaries of the south-east of England to the great geological escarpments, due in great measure to the early settlement of these regions by our ancestors on districts affording a water supply (p. 278). Journ. Anthropol. Inst. vol. iii. p. 32.

Professor Hull shows that along the valley of the Evenlode, and other parts of the district, villages are planted wherever there are copious springs combined with a dry situation; some of these villages are perhaps as old as the Norman Conquest, and have not altered much in size through several centuries (p. 218). Mem. Geol Surv. 1859, p. 8.

Mr. Fox-Strangways, in his description of the country around Scarborough and Filey, shows how geological structure has influenced the selection of sites for villages, nearly all being "on either edge of the great clay valley, where springs of beautiful calcareous water burst out" (Mem. Geol. Surv. 1880).

Prof. Buckman describes the outcrop of the Cornbrash between Witham Friary and Hardway to Wincanton, as marked by a line of villages, due, not only to the fertility of the soil of the Cornbrash, but to its being a collecting ground for water kept up by the impervious Forest Marble beneath (p. 353).

Dr. Lycett remarks that in the Cotteswold district to the south-east of Stroud, the course of the Fullers Earth upon the flanks of the valleys is indicated by a zone of cottages and gardens, which often afford a striking contrast to the barren slopes of the Inferior Oolite beneath. This association of population and fertility is due to the springs of water which are emitted from the junction of the Fullers Earth with the Great Oolite (The Cotteswold Hills, p. 86).

The subject of water and water supply has for some years past occupied much attention, especially as the increase of the population in towns and cities required a further supply for various sanitary and manufacturing purposes; while the defective state and frequent contamination of water in rural villages from the proximity of shallow wells to cesspits and ashpits necessitated some further remedial measures. Prof. Prestwich remarks, "Although the flagrant sources of contamination are generally removed from our large towns, they still too often lurk in hidden or forgotten corners, while in hundreds of smaller towns and villages, and in thousands of country houses, the plague-spot still exists in almost all its foulness and intensity" (Lecture on Water Supply, Oxford, 1876).

Royal and Parliamentary Commissions in 1868, 1874, 1877, 1878, have collected much information on water-supply and the state of our rivers; Committees have been appointed on Rivers conservation, and for inquiry into the Underground Circulation of water (Brit. Assoc. 1874–75), and many contributions have been made to scientific institutions, on the storage, flow, and distribution of water, besides special works by Prof. Prestwich, Prof. Ansted, Mr. Lucas, Mr. S. Hughes, and other private authors, having more or less reference to water supply.

Many valuable reports were obtained by the Congress on National Water Supply convened by the Council of the Society of Arts in 1878–79. See Journ. Soc. of Arts, 1879. To this Congress Mr. De Rance was a contributor, and the papers then read, and another "On the Secondary Rocks of England as a source of Water Supply" (Manch. Geol. Soc., March, 1878), combined with the "Lectures on Water Supply" to the Wigan Mining School in 1876, form the basis of the present work. The object being to show not only the character and quantity of the water supplied to every town in England and Wales, but to afford data for estimating the volume of water available and the quantity required for consumption (according to the population census of 1881) in the different groups of river-basins, by carefully describing the area of the principal geological formations, and the amount of rainfall in each basin.

The first chapter treats of rainfall and its percolation. As all fresh-water is derived either from rain or snow, the distribution of the rainfall (less the loss by evaporation and absorption by plants and animals), and its subsequent accumulation either in lakes, rivers, or in underground circulation, are the available sources of supply.

Mr. De Rance states—"According to Mr. Symons' map, the rainfall of England exceeds 25 inches per annum throughout the entire area lying west of a line ranging from Shields to Reading, whilst west of a line trending from Shields to Start Point, the rainfall around the Lower Palæozoic rocks forming the elevated tracts of the English Lake District, of Wales, and of Dartmoor, amounts to more than 75 inches per annum. With so large an area, receiving so abundant a rainfall, the existing absence of an efficient water-supply, not only for our larger cities, but for our rural population, becomes a matter of surprise, and an inquiry into the causes, a subject of considerable importance" (p. 1).

The Hyetographical map indicates the annual amount of rainfall arranged under six divisions, varying from 23 to 90 inches.

After speaking of the disadvantage of large artificial reservoirs from their sometimes covering extensive areas of good meadow ground, in comparison to natural lakes as reservoirs, the author says. "The great value and agricultural character of the land consisting of the Newer Palæozoic, Secondary and Tertiary rocks, make an inquiry into the amount of water they are capable of yielding when penetrated by deep wells, which do not necessitate large expanses of reservoir space, a matter of considerable interest. Classified according to their water-yielding characters, they may be described as impermeable, pervious, and suprapervious, the latter consisting of impermeable strata resting on a pervious rock" (p. 5).

The Hydro-geological map (p. 30) shows the areas occupied by these rocks, to which is added a "partially porous" division.

The storage capacity of rocks is also considered, and a table (p. 19) shows the varying quantity of water held in the pores of various rocks, per cubic foot.

In the second chapter, which is chiefly taken from the 6th Report of the Rivers Pollution Commission (1874), the composition and varying character of waters as derived from or flowing over different geological strata, are successively described in relation to their hardness, soluble contents, and organic impurities, accompanied by a table of analyses of water derived from Oolitic rocks, from which it appears, that although these rocks for the purification and storage of water are equal, if not superior to the Chalk, the analyses show that great care should be exercised to cut off surface contamination in deep wells, and that shallow wells are absolutely unsafe. (pp. 41–44).

Much useful information is given in this chapter as to the solid impurities and hardness of different waters from various rocks, and their fitness for domestic purposes. While the use of hard water for washing and the generation of steam is a disadvantage, it may be noticed that the presence of sulphate of lime in the Burton water is believed to give it a pre-eminence in the manufacture of beer, and it is estimated that the gypsum derived from the water used in brewing 1000 barrels of ale would be 250 lbs. (p. 112). Of the water derived from the Burton Valley gravels, and used in various operations of brewing, probably not less than 1,050,000 lbs. of gypsum will be disposed of, which Mr. Molyneux considers will not represent one-tenth of the actual amount of gypsum being annually carried to the sea (p. 113, and Burton-on-Trent, 1869, p. 208).

The following chapters (iii. to xxxiv. pp. 47–575), forming the body of the work, are devoted to the special description of the river-basins of England and Wales. For the 215 river basins delineated on the Catchment-basin Map of the Ordnance Survey, various groupings have been suggested, especially in the papers contributed to the Congress before mentioned by Messrs. Lucas, Atchison, Penning, and Prof. Ansted. In this work Mr. De Rance has adopted 13 main groups or drainage areas, the distribution of which is shown on a coloured map (p. 47). Under each of the great divisions the included minor basins are fully described,—giving the length of the streams, their area in square miles, the rainfall and highest point of watershed, together with the chief towns situated within them, their acreage, population, amount of water supply and rateable value.

Throughout these chapters there is a great amount of statistical data, very useful for reference, but difficult to abstract, interspersed with much interesting information,—on the different water-partings of the country and their importance (pp. 47, 135, 174), on the limestones and sandstones of the Permian rocks (p. 59), on the relative value of hard and soft water on health, and even on the death rate (p. 39), on rainfall received in one basin flowing underground into another (pp. 100–102), on the Lower Greensand as a source of water supply (pp. 24, 43), on the London water supply (pp. 179, 184, 194, 243), on the area of the Cretaceous rocks, and their water-bearing capability (p. 136), and on Artesian wells,—besides noticing many localities where these wells are used, Mr. De

Rance has collected the facts and opinions of various authors who have investigated the subject, as to the capability of these wells yielding a good and permanent supply, especially in connexion with the Metropolis (pp. 183, 187, 241).

That they may be an effective source, under certain conditions, there can be little doubt; but the calculation must be based not upon the amount of rainfall over the exposed surface area of the permeable rock, but on the probable quantity which finds its way to the underground reservoir to supply the Artesian well (see pp. 183–4).

It is well known that the level of the water in the London artesian wells, derived from the Lower Tertiary sands and Upper Chalk, has steadily decreased with the increase of their number; still it was expected by sinking to lower permeable strata, that a better supply might be obtained, and thus obviate the use of the Thames and Lea streams. The Rivers Pollution Commission (Sixth Report) believe that within a forty mile radius of London a sufficient volume of deep-well and spring water can be obtained for the wants of the metropolis, from the Chalk and Upper Greensand; but as Dr. John Evans, F.R.S., remarks,—while they admit that any water drawn from the subterranean reservoir in the Chalk by artificial means will be at the expense of the streams which now flow through the valleys in the Chalk area, they do not give even a passing consideration to the effect upon that area of abstracting from it its natural supply of water, how it will affect the existing wells, the mill-streams, and the fertility of the district dependent on the supply of moisture (Ann. Address, Geol. Soc., 1876, p. 70).

The Royal Commission on Water Supply laid great stress on the underground store of water supposed to be contained in the Lower Greensand (Report, 1869, p. 87), and which had been previously advocated by Prof. Prestwich in his "Water-bearing Strata," 1851.

The experience since gained by the borings at present made is not favourable to the scheme (p. 243), as far as the immediate neighbourhood of London is concerned.

In other districts, however, the Lower Greensand has yielded effective supplies; thus, at Cambridge, although Mr. De Rance mentions but one artesian well at Harston 200 feet deep (p. 154), Prof. Prestwich states that artesian wells are numerous, and that much of the water is evidently pure and good (Water-bearing Strata, 1851, pp. 90, 167, 183, 193). Also Prof. Bonney, Camb. Geol. p. 80.

There are many artesian wells at Harston and all round this Gault district which draw their water from the Lower Greensand, some of which overflow. A well has been bored through the Gault at Cherry Hinton for the Cambridge water works. M.G.S. Camb. Dist. p. 129.

Again, in Bedfordshire, Prof. Chapman remarks (Phil. Mag. 1852, 2nd ser. vol. iv. p. 102): "There are perhaps few localities in which the subject of Artesian wells can be better studied than in the valley between Silsoe and Barton-in-the-Clay; the latter village lying under the bold escarpment of the Chalk with its projecting spurs and rounded hollow coombes, and the former on the opposing range of the Lower Greensand." In this valley the Lower Greensand is covered by impermeable calcareo-argillaceous strata (Gault, Upper Greensand, and Chalk Marl), so that within an area of ten square miles, from one to two hundred borings have been executed; and in a great number of instances the bore-holes produce an overflowing stream. The water is slightly chalybeate, its temperature is 51° F. and is generally considered to be very wholesome; the abstraction from these wells was estimated in 1852 at three to four million gallons daily over the area.

The distribution of population in relation to water-demand, on the average of 31 gallons per head per day, is shown on a map (p. 575), arranged under 14 sections, and the last chapter treats on the propagation of epidemics by potable waters.

We have attempted to notice generally some of the facts and suggestions brought together by Mr. De Rance, the result of much labour, and which are systematically and usefully arranged.

To those immediately interested in water supply the volume will be a necessary acquisition, while the general reader will find many interesting points connected with the present state of the water question and its varied sources of supply and distribution.

The three copious indexes—1. Of the authors cited; 2. The distribution of lakes, rivers, etc.; and 3. The urban sanitary districts—will afford facility for any reference required.

A more prominent heading at the commencement of each of the thirteen catchment basins, with the same numerals affixed as on the map, and a fuller reference to the works of many of the authors cited, would have been useful. A few typographical errors occur, such as the word "*distribution*" used instead of "destruction," p. 51,[1] River *Oak* for Ock, p. 215, *Ludlow* for Wenlock, p. 386, *Brentford* for Watford, p. 193, and several others of minor importance.

J. M.

## REPORTS AND PROCEEDINGS.

### GEOLOGICAL SOCIETY OF LONDON.

December 21, 1881.—R. Etheridge, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "The Torridon Sandstone in relation to the Ordovician Rocks of the Northern Highlands." By C. Callaway, Esq., M.A., D.Sc., F.G.S.

The author pointed out that the apparent difference in dip between the Torridon sandstone and the overlying quartzite in the neighbourhood of Loch Broom was due to some markings in the former which suggested a direction of bedding which was not the real one, and that the one rock passed gradually into the other. The two are perfectly conformable at Strath Auchall, where the junction can be well studied; also between Unaport and Strath Kennort, on the north side of Loch Assynt and south of Unaport.

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[1] Mr. Topley remarks, "The peat-bogs acted as large sponges, or as compensating reservoirs, but they were being yearly destroyed."—Proc. Inst. Civ. Eng. xlv. p. 90.

The author then considers that there is proof of the conformity of the quartzites with the Torridon sandstone, and that there is no unconformity as generally suggested. In this case it appears to him to follow that the Torridon sandstone must be either Ordovician or Upper Cambrian in age, and that the former is more probable, as the overlying quartzite is not more than some 500 feet thick, so that the united thickness of the two hardly exceeds at most that of the Arenigs of Shropshire or South Wales.

2. "The Pre-Cambrian (Archæan) Rocks of Shropshire." Part II. By C. Callaway, Esq., D.Sc., F.G.S.

The author described the western axis of Archæan rocks in Shropshire, which runs roughly parallel with the Wrekin and Caradoc ranges at a distance of from six to seven miles, the intervening district being chiefly occupied by the Longmynd rocks. They are exposed over a line about 11 miles long, forming usually low hills or ridges trending S.S.W. Pontsford Hill, however, at the northern end projects prominently into the Shropshire plain. In the lower part of this hill are purple rhyolites banded and spherulitic, the latter structure being exhibited in chalcedony filling cavities of the rock. Compact dolerite forms the upper part of the hill. At Lyd's Hole a junction of the Cambrian Grits with the underlying rhyolites is seen. Conglomerates containing the latter rock also occur. At Gatten Lodge are purple hornstones; at Knoll's Ridge somewhat similar rocks, with others that appear intrusive; at Cold Hill purple hornstone and breccia; and at Chissol a greenish hornstone. The rocks of Knoll's Wood are probably about on the horizon of those of Caer Caradoc, grits perhaps derived from a gneissic area. Stratigraphical as well as lithological considerations lead the author to the opinion that the series is Pre-Cambrian.

3. "The Red Sands of the Arabian Desert." By J. A. Phillips, Esq., F.R.S., F.G.S.

The author described the general characters of the Nefûd, or great red desert of Northern Arabia, which consists of a series of parallel ridges of considerable elevation, no doubt at some period piled up by the action of strong winds, but now no longer undergoing much change of position, as is evidenced by the fact that sticks and stones remain for many days uncovered on the surface, and that the landmarks made use of in crossing the desert appear to be permanent. A specimen of the sand of this desert received by the author from Lady Anne Blunt, is composed of well-rounded red grains from $\frac{1}{50}$ to $\frac{1}{30}$ inch in their longest diameter, which are rendered colourless by treatment with hydrochloric acid, the material thus removed amounting to ·21 per cent., or a little more than $\frac{1}{500}$ of the total weight operated upon, and consisting of ferric oxide with a small quantity of alumina. The sand dried after the action of hydrochloric acid gave on analysis:—

| | |
|---|---|
| Silica ... ... ... ... ... ... ... ... ... | 98·53 |
| Protoxide of iron ... ... ... ... ... ... ... | 0·28 |
| Alumina ... ... ... ... ... ... ... ... | 0·88 |
| Lime, magnesia, and alkalies ... ... ... | trace. |
| | 99·69 |

The external coating of ferric oxide must therefore have been deposited subsequently to the rounding of the grains; it could not have been derived from an external decomposition of the grains themselves; and it becomes difficult to imagine in what manner the superficial red coating can have been produced. The author compared these grains with those of the millet-seed sandstones of Triassic age, with which they closely agree in character, but remarked that the conditions of their occurrence were apparently quite different.

4. "Analyses of five rocks from the Charnwood Forest District." By E. E. Berry, Esq. Communicated, with Notes, by Prof. T. G. Bonney, F.R.S., Sec. G.S.

These analyses are of hornblendic granite from Mount Sorrel, "syenite" from Markfield, Garendon, and Croft Hill, and "porphyroid" from Sharpley. In the main they confirm the views expressed by Messrs. Hill and Bonney in their communications on the subject, arrived at from microscopic examination, as to the nature and affinities of these rocks.

## CORRESPONDENCE.

### THE FOLKESTONE BEDS.

Sir,—In the discussion at the meeting of the Geological Society on Dec. 7, 1881, it was mentioned by Prof. Judd that, according to Dr. Barrois, the Folkestone beds belonged rather to the Gault than to the Neocomian.

It is well known that the top bed of the glauconitic grits at Copt Point contain, as mentioned by Mr. Topley (Q.J.G.S. vol. xxiv. p. 47) *Amm. mammillaris*, *A. Beudanti*, *Inoceramus Salamoni*, to which may be added *I. concentricus*, etc., and for this reason, in 1860, M. Gaudry proposed to separate this horizon at Folkestone and Wissant from the Neocomian, and place it in the Gault. Probably most observers will agree to draw the line of separation by the former Ammonite.

But below the mammillaris-bed at Folkestone, we begin to find the large *Exogyra sinuata;* in my notes I find it stated that it is not uncommon, whilst *Janira quinquecostata* was also seen in the grits at Copt Point. Moreover these observations are not unsupported. In the Woodwardian Museum are a series of fossils from these grits and the sands between them from near Copt Point, collected by Messrs. H. and W. Keeping, which make the Neocomian age of the Folkstone beds a matter of no uncertainty. These are from the grits, *Ex. sinuata*, *Pecten orbicularis*, *Janira quinquecostata*, *Avicula pectinata*. *Cucullæa fibrosa;* from the sands, *Lucina Vectensis*, *Trigonia alæformis*, *Pectunculus cf. umbonatus*, Sow., *Cucullæa*, *Astarte numismalis*, D'Orb., *Tellina*, *Rhynchonella cf. elegans*, Sow.

Dr. Barrois has already noted the presence of *Ost. aquila (sinuata)* in the Folkestone sands (Ann. Soc. Géol. Nord. vol. ii. p. 46), but I was not aware that it occurred in the same bed with *A. mammillaris* as he implies, though doubtless it does so in the Argonne, etc. (*ibid.* pp. 23, 34, 58). Probably English geologists will still continue indisposed to classify the Folkestone, the Sandgate, and the Hythe *beds as proposed* (*ibid.* p. 56) with the Gault.

We may add that the mammillaris-bed at Copt Point yielded to the researches of Messrs. H. and W. Keeping an example of *Thetis minor* phosphatized. Of course it may be argued that it was derived.

WOODWARDIAN MUSEUM, CAMBRIDGE. E. B. TAWNEY.

## OBITUARY.

### SIR ANTONIO BRADY, KNT., J.P., F.G.S.

BORN 1811; DIED 12TH DECEMBER, 1881.

IT is always with a keen feeling of regret that we record the loss from the scientific ranks of men whose faces, as well as their names, were familiar to us by long association, and who were for years fellow-workers in the same geological area. Such a one was Sir Antonio Brady, F.G.S., who passed from among us on the 12th of December, 1881, from an affection of the heart.

He was the eldest son of the late Mr. Anthony Brady, of the Royal William Victualling Yard, Plymouth, by his marriage with Marianne, daughter of Mr. Francis Perigal. Born in 1811, he entered the Civil Service of the Navy as a junior clerk in the Victualling Yard, Deptford, more than fifty years since. After serving in various offices, having been promoted to head-quarters, he became head of the Contract Office and Registrar of Public Securities in 1854, subsequently assisting to reorganize that office. After the reorganization of the office he was appointed first superintendent of the Purchase and Contract Department, retiring from the service in 1870, when he received the honour of knighthood. Since his retirement from the public service, Sir Antonio has devoted his energies to the service of the public, and having taken a leading part in the preservation of Epping Forest for the people, was appointed a judge in the "Verderer's Court for the Forest of Epping." He also took great interest in the work of church extension, and was a member of the Ray, the Palæontographical and Geological Societies. He was in the Commission of the Peace for Westminster. The deceased married, in 1837, Maria, eldest daughter of the late Mr. George Kelner, of Ipswich, by whom he leaves a son, the Rev. Nicholas Brady, M.A., and two daughters.

But it is in his character of a geologist that we must now speak of Sir Antonio Brady. So long ago as 1844 his attention was attracted to the wonderful deposits of brickearth which occupy the Valley of the Roding at Ilford, within a mile of his residence. Encouraged by Professor Owen and other eminent palæontologists, whose society he so loved to enjoy at his hospitable home at Maryland Point, Stratford, he commenced to collect the rich series of Mammalian remains which the Thames Valley brickearths yield. Owing, however, to their porous nature, the bones had lost, during their long interment, all their gelatine, and the earlier "finds," when exhumed, were so soft and friable that they crumbled beneath the touch, and it was not until fresh gelatine had been introduced that it was found possible to preserve these magnificent remains of the old inhabitants of this district. In his Catalogue of the Pleistocene Mammalia from Ilford, Essex (1874, 4to. printed for private circulation only), Sir Antonio Brady pays a just tribute of respect to the genius and ability of his first instructor in the art of preserving fossil bones, and acknowledges that he was indebted to Mr. William Davies, F.G.S., of the British Museum, for the preservation of most of the larger specimens in his collection.

Some idea may be formed of the enormous riches of this deposit when we find that an amateur, in his leisure hours, was able to amass nearly one thousand specimens of Mammalia from a single locality, comprising: *Felis spelæa*, *Canis vulpes*, *Ursus*, sp., *Elephas primigenius*, *E. antiquus*, *Rhinoceros leptorhinus*, *R. megarhinus*, *R. tichorhinus*, *Equus fossilis*, *Megaceros Hibernicus*, *Cervus elaphus*, *C.* sp., *Bison priscus*, *Bos primigenius*, *Hippopotamus*, sp. To this interesting series of fossil remains of the old fauna of the Thames Valley, we may add that the subsequent researches of Prof. Boyd Dawkins, F.R.S., and R. W. Cheadle, Esq. F.G.S., have added the "Musk-Ox," *Ovibos moschatus*, and the labours of F. C. J. Spurrell, Esq., F.G.S., the "Lemming." We have thus presented to us in this area the conjunction of Northern and Southern forms of land-animals as marvellous as that which modern London exhibits to-day, in its assemblage of specimens of the genus Homo, from every clime. For with the *Hippopotamus*, the *Rhinoceros*, and the Lion from the south, we have also in abundance the *Cyrena fluminalis*, a shell now characteristic of the Valley of the Nile and the rivers of India and China: whilst from the north, the "Musk-Ox," the Reindeer, the Elk,[1] and the Lemming advance to meet them.

To Sir Antonio Brady, then, we are indebted for a most valuable collection of Pleistocene Mammalia, now happily preserved in the British Museum of Natural History, Cromwell Road. Nor must we omit to mention that he strove by his presence, as a resident at Stratford, and by his constant acts of kindness and hospitality to the workmen, and by the *largesse* which he freely gave, to rescue from destruction these interesting relics of a pre-historic age, which now help to swell the magnificent series of our National Museum.—H. W.—("*Nature*," Dec. 22, 1881.)

## CHARLES MOORE, F.G.S.

BORN AT ILMINSTER, 1814; DIED AT BATH, DEC. 1881.

THERE are some men who are induced by example and the influence of others to become geologists; there are a few men who are to the manner born. Charles Moore was one of those self-taught naturalists, who, if not born a "hammerer," took to it from boyhood. In the quarries of the Upper White Lias, near Ilminster, at which place Charles Moore was born, there are found large numbers of oblong oval nodules which, with the ready assimilation characteristic of boyhood, were found excellent for bowling along the road. He was, as a schoolboy, one day amusing himself thus with two nodules in the road, when, in striking together violently, one of the nodules split open and, to his surprise, revealed a fossil fish inside. His curiosity was instantly aroused as to how such an organism could have got into such an unlikely place as the middle of a hard round stone. He sought out a book on geology, and read it with avidity, and the keen interest thus first awakened never flagged even to the end. From this early date Charles Moore became a collector of fossils, and an accumulator of geological facts, and before he removed from Ilminster to Bath he had already formed a considerable collection, and become thoroughly acquainted with the geology of the district in which he lived. Brought up to the business of a Bookseller, he was for some time engaged at the Grand Pump Room Library, Bath. He subsequently married the only daughter of Mr. Deare, of Widcombe, and from that time he relinquished business and devoted his whole life and energy to geological investigations, and to the service of the City of Bath, of which he was an Alderman. Those who can recall the meeting of the British Association at Bath, in 1864, will doubtless remember Mr. Charles Moore's paper "On the Geology of the South-West of England,"[1] in which he described the "Rhætic Beds," a group of strata which had before escaped the notice of geologists in this country. These beds, situated intermediate between the Lias and the Trias, so largely developed in the Rhætic Alps, are but thinly represented in this country; they are nevertheless of the highest palæontological interest. Mr. Moore described the contents of three cartloads of detritus of Rhætic Beds which had been washed into a fissure of Carboniferous Limestone at Holwell, near Frome, Somerset. From this he exhibited twenty-nine teeth of one of the oldest known Mammals (*Microlestes Moorei*, Owen, see Pal. Soc. vol. xxiv. 1870. Mon. British Mesozoic Mammals, p. 6, pl. i. figs. 1-13), three only having been previously found in so old a stratum (viz. *Microlestes antiquus*, Plieninger, from the Rhætic bone bed at Diegerloch, Wurtemberg). Mr. Moore also showed relics of nine genera of reptiles and fifteen genera of fishes, most of which were new to this country. He produced before the meeting 70,000 teeth of *Lophodus*, alone, as the result of this labour, and he stated that the hand picking, under a lens, of this three cartloads of clay had probably yielded him one million organic remains.

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[1] There is evidence of the true Elk (*Alces palmatus*) from the somewhat later deposits of Walthamstow, Essex. (See GEOL. MAG. 1869, pp. 385–388.)

Those present will recall the amusing and interesting description he gave of those wonderful nodules from the Upper Lias containing remains of Insects, Crustaceans, Fishes, Reptiles, and Plants; and how he riveted the attention of his audience by affirming that he could say with certainty that one contained the tail of a *Pachycormus*, that a second contained a head of a similar fish, a third a perfect fish, another a Cuttle-fish with its cuttle-bone and ink-bag. Then, hammer in hand, Mr. Moore proceeded to open them *seriatim*, when to the great amusement and delight of the section, the fish previously indicated, and the Cuttle-fish with its dried ink-bag well preserved, were duly discovered and exhibited. Numbers of fossil fishes and perfect specimens of *Ichthyosauri* and *Teleosauri* were also exhibited, all collected by Mr. Moore himself.

Mr. Moore's contributions to science are very numerous, they amount to over thirty memoirs, most of which are to be found in the Quarterly Journal of the Geological Society, the Annual Volumes of Reports of the British Association, the Transactions of the Bath Literary and Philosophical Association, and other local Societies of which he was a member, and in the volumes of the GEOL. MAG.

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[1] See Geol. Mag. 1864, p. 235.

But the chief memorial of his life-long labours is to be seen in that charming Museum of the fossils of his native county, arranged and preserved with so much care by Mr. Moore's own hands, in the Literary Institution at Bath.

Much as its treasures may be coveted by English and foreign savans, it is to be hoped that his fellow-townsmen will readily subscribe more than its estimated value (whatever that may be), in order to enjoy the gratification of seeing still in their midst one of the most beautiful and interesting *local* collections to be found in all England.

It is to be regretted that Mr. Moore's unexpected death has prevented our gaining a fuller knowledge of the early years of this eminently hard-working geologist. In his life-time he did much to induce others to take up the science, and he was himself a bright example of what may be accomplished with quite ordinary opportunities for self-improvement, with delicate health, a very small income, but indomitable energy and an earnest love of science.—H.W.

## EDWARD WILLIAM BINNEY, F.R.S., F.G.S.

BORN 1812; DIED 1881.

WAS born at Morton, in Nottinghamshire, in 1812, and died in Manchester, on the 19th of December, 1881. He was articled to a solicitor in Chesterfield, and after spending a short time in London, finally settled in Manchester in 1836. He was a tall, strong, and robust man, fond of science for its own sake, and seemed to have been formed by nature for a naturalist and geologist. About two years after his residence here, he, with a few other scientific friends, founded the Manchester Geological Society—the late Lord Francis Egerton, M.P., F.G.S., being the first President, and Messrs. E. W. Binney and J. F. Bateman, the first Hon. Secretaries. He afterwards occupied the President's Chair in 1857–59, again in 1865–67, and on the 25th of October, 1881, was chairman at the last Council Meeting of the Society. Mr. Binney was elected a Fellow of the Royal Society in 1856, and of the London Geological Society in 1853, and at the time of his death was President of the Literary and Philosophical Society of Manchester. Mr. Binney's industry is evidenced by the number of his scientific papers and notes, of which about 100 have been read or printed. They include reports and contributions to the various Geological Societies, British Association, Philosophical Magazine, etc. For the Palæontographical Society, of which he was a Vice-President, he contributed a monograph on the "Structure of Fossil Plants found in the Carboniferous Strata," of which four parts were issued between the years 1868 and 1875; the text for its completion is in a forward state, and it is expected will shortly be published.—J. E. F.

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## ORIGINAL ARTICLES.

### I.—ON THE HEADON BEDS OF THE WESTERN EXTREMITY OF THE ISLE OF WIGHT.

By A. H. S. LUCAS, M.A. Oxon, B.Sc., F.G.S.

THE recent answer[1] to the recent questioning[2] of the hitherto accepted correlations of the beds of the Lower Fluvio-Marine Tertiaries in the Isle of Wight and South Hants does not seem to be universally accepted as decisive. It is obviously impossible for foreign geologists to institute useful comparisons between British and foreign subdivisions so long as we in England are quite at variance on the stratigraphical and palæontological *facts* of the beds in question. Yet these conflicting readings are what we have to offer them at present.

There has been no lack of able workers on the ground. The succession proposed by Forbes, and elaborated by Bristow, agreed and in no way conflicted with the previous stratigraphical results of such observers as Prestwich and Wright. Lastly, we have the elaborate defence of the Survey views in the memoir of Messrs. Keeping and Tawney, comprising a mass of evidence as to both the order of the strata and the distribution of life-forms, evidence peculiarly valuable because of a kind not easily obtained, viz. that derived from years of continuous observation of these ever-changing cliff-fronts.

The general relations of the whole group can only be satisfactorily determined after the primary question of the continuity or discontinuity of the Colwell Bay and Headon Hill beds is settled. So far there were two very definite views—with a perfectly distinct issue, that the brackish-marine beds of Colwell Bay correspond to the brackish-marine beds of Headon Hill which have been seen, or that they correspond to some higher marine beds which have not been seen; and the arguments for each view were fairly before geologists. But, in a paper recently published,[3] Prof. Blake has advanced an entirely new correlation, and adduces stratigraphical evidence in its favour. The observations there recorded do not agree in some critical cases with those of Messrs. Keeping and Tawney, though still less so with those of Prof. Judd. There seems therefore a danger that the facts and lines of argument may again be confused. The following remarks are offered in the hope of contributing to recall attention to the certified facts. They are based on notes and recollections of five days spent in working the cliffs at the beginning of last year. I had read Forbes's memoir and Prof. Judd's paper, but had not seen Messrs. Keeping and Tawney's paper, but was independently brought to the same conviction as they as to the accuracy of the Survey reading. No attempt will be made to consider the relation of these beds to the deposits exposed at Hordwell, Brockenhurst, or White Cliff Bay, as it is especially desirable to concentrate attention first on the determination of the identity or distinctness of these adjacent beds in the west end of the Isle of Wight.

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[1] Q. J. G. S. vol. xxxvii. p. 85.
[2] Q. J. G. S. vol. xxxvi. p. 137.
[3] Proceedings Geol. Assoc. vol. vii. p. 151.

One difficulty in reading the sections in Headon Hill arises from the constant denudation of the yielding materials of the strata, which pour down in taluses and obscure the lower beds. Only *vertical* cliff-faces are at all reliable. And it is quite impossible, from this cause, *at any one time,* for any one not perfectly familiar with the exact locale of the smaller subdivisions to trace out the complete sequence. The standard sections are the result of a synthesis of separate observations, now one series of smaller beds appearing *in situ,* and now another, till by a combination of results the whole section is completed. The only way in which a passing observer can verify the standard sections is to note whether the part of the cliff exposed at the time is in accurate correspondence with the same part of the section. During our stay, for instance (Jan. 4–9, 1881), the marine series were well shown at the S.W. corner of the Hill, while at the N.E. only the upper portion was seen, the white *Cerithium* band standing out conspicuously, at the height of 110 feet above the sea, in a clean vertical face, from which a former front had slipped down in a talus right on to the Lower Headon Limestone, bringing the beds quite away from their proper position.

Another difficulty in making out the arrangement of these beds is the normal variability in thickness and character of fresh-water beds, and especially of Limestones, when pursued horizontally. It behoves section-makers to state with the utmost exactitude the spots at which their sections are taken. The Osborne Limestone, 18 ft. thick at Heatherwood Point, notoriously thins out to the E., and is wanting altogether under the cottage. As noted by Forbes in a wood-cut (Memoir, p. 132), one of the Limestones in his time could be seen at one spot to increase quite suddenly owing to a basal thickening. The thickness of the Great Limestone of Headon Hill varies very greatly in the hill itself, as is well pointed out by Prof. Blake "at the expense of the sand" beneath. Such lenticular masses can hardly be strictly correlated with other beds in adjacent areas after they have thinned out. But the more extensive beds in which they are intercalated can very often be directly associated with lateral extensions, and thus the place of the Limestone be fixed. Thus the Osborne Limestone is included in distinctive clays and mottled marls, and these are found to thicken correspondingly when the Limestone thins out. The age of the Limestone is thus at once determined. When the Limestone bands are *continuous,* they are, of course, of the very greatest service stratigraphically, because they are conspicuous and resist denudation better than the associated sands and marls. Thus the great Headon Limestone from its lenticular contour cannot serve as a well-defined horizon save in the hill itself, where it is continuous. In Colwell Bay, if we recognize its coincidence with the 1ft. 4in. buff *Limnea* Limestone, we must do so from the correspondences of superior and inferior beds; for this Colwell Bay Limestone might be another similar intercalation.

We think the stratigraphical evidence alone yields very clear results. In Headon Hill we can obtain a standard section reaching from the top of undoubted Headon Hill Sands to the base of undoubted Bembridge Limestone. Such a standard section is deduced by combining vertical sections made at various points in the Hill. There is no break in the strata. The vertical section of the Survey near Heatherwood Point includes the Bembridge Limestone, the Osborne Marls, the Osborne Limestone, the Great Upper Headon Limestone, the brackish-marine, and the Lower Headon Limestone with a few beds below. It practically agrees with that of Prof. Blake taken about the middle of the W. face of the Hill. Near the S.W. corner, again, a vertical section includes the Osborne Limestone, the Great Limestone, the brackish-marine, the Lower Headon Limestone, and the Headon Hill Sands. As no vertical section at this point has been published, though details obtained from it are implied in the horizontal section D of the Survey, we give a few measurements of the height above sea-level of critical points, that of the Sands fixing the spot at which the section was observed, somewhat to the N. of Alum Bay Chine.

| | |
|---|---|
| Top of Headon Hill Sands | 24½ ft. |
| Base of Lower Headon Limestone (6ft. thick) | 106½ ft. |
| Base of Great Planorbis Limestone | 144½ ft. |
| Base of Osborne Limestone | 184½ ft. |

The Lower Headon Beds were so obscured by the "mud glaciers" that we did not venture on a detailed record. Of the brackish-marine we preserved the following memorandum. Below the freshwater Sands beneath the Great Limestone we found, as we worked down,

| | |
|---|---|
| "Blue clay with *Cerithia* (*concavum* and *ventricosum*) | 4ft. 6in. |
| Ferruginous Sand | 2ft. 8in. |
| Blue clay | 7ft. 3in. |
| An oyster bed | 2ft. 6in. |
| Blue clay with *C. concavum* | 8ft. |
| Brown clay with Lignite | 1ft. 3in. |
| A zone of *Cyrena obovata* | 1ft. |
| Ferruginous Sands | 1ft. |
| A zone of *Cyrena obovata* | 1ft. |
| Lignite | 3 or 4 in. |
| Blue clay | 2ft." |

We found fragments of *Cytherea incrassata* in the clays of the middle zones, which with *Fusus labiatus*, *Ostræa velata*, *Natica depressa*, etc., marked off a larger marine series below from a smaller brackish series with the *Cerithia*, etc., above. We have no record of fossils in our note from the lowest clay, while the Lignite and *Cyrena* beds above it show a similar but reverse transition from fresh-water to marine conditions.

Near the N.E. angle of Headon Hill we have another very definite section, which can be verified more or less at any time, directly under the cottage. This has been fully done by Messrs. Keeping and Tawney,[1] the former of whom lived for many years in the neighbourhood. We made some measurements which entirely confirm their observations, though we had not seen their section at the time. We found the Bembridge Limestone reaching 21 ft. below the base line of the cottage, and traced the red and green mottled Osborne marls some 19 ft. below the limestone in the vertical cliff, and they gave no evidence of coming to an end. The "Brockenhurst" beds should be about here according to Prof. Judd's section,[2] but we could see nothing of them. The Great Limestone rested on a deficiency of sands here. The upper brackish beds of the Middle series were alone exposed *in situ*, as mentioned above, at a height of 110 ft. above sea-level. The marine beds had slipped down, and we obtained many of the typical shells on the slopes just above the Lower Headon Limestone, where Prof. Blake describes them as *in situ*. We did not even venture on measuring the height of the Lower Limestone, as it seemed to us uncertain whether it was exactly in position, or whether portions had advanced *en masse* in a roll seawards. This certainly confirms the Rev. O. Fisher's suggestion as to the cause of a previous erroneous interpretation. Putting together then these four vertical Headon Hill sections, we have a very clear succession of strata. The one bed which thins out in the Hill is the Osborne Limestone. The rest are continuous.

The extensive denudation N. of Widdick Chine, and the gentle dip of the strata, forbid any further comprehensive vertical sections at particular spots. The next step is to tabulate the beds, on their successive emergence above sea-level as we proceed N. to Cliff End. The beds claimed as Headon have been measured carefully by Dr. Wright, and by Messrs. Keeping and Tawney, and the Osborne beds by Edward Forbes, and the main divisions are so conspicuous even as one walks over the ground, that about the succession here there can be no dispute. Then there comes the question as to how far the succession in the standard Colwell-Totland Bays section tallies with that of the standard Headon Hill section. The upper limit to both, the Bembridge Limestone, is most useful as restricting possibilities to accessible ground in both cases. It is universally admitted as occurring at the top of both sections. The Osborne series of the two localities are tabulated successively by Forbes (Mem. p. 78 and p. 81), and the general agreement (minus at Cliff End the limestone of Heatherwood Point) is evident. These Osborne marls may still be seen under the grass behind the cliff immediately S. of the Battery, as we found by a little digging. That the series was an unprofitable one we had keenly felt in Museums, with its ill-preserved and poorly characteristic fauna, but its great use as a conspicuous, well-developed, and easily recognized member of the fresh-water series was brought home to us in the field.

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[1] Q.J.G.S. vol. xxxvii. pp. 88, *seq.*

[2] Q.J.G.S. vol. xxxvi. pl. vii. fig. 2.

The next beds to compare are those between these admitted Osborne marls and the brackish-marine series of Colwell Bay, and those between the *similar* mottled marls and a *similar* brackish-marine series in Headon Hill. Messrs. Keeping and Tawney give details of both localities. We have also Dr. Wright's section of Colwell Bay, and Prof. Blake's lithological notes on both localities. There is practical agreement as to the facts of the succession in all published observations. Both series begin above with a thickness of 12 to 15 ft. of clays with *Potamomya gregaria* and *Paludina lenta*, which are beautifully preserved. Below the Potamomya clays in Colwell Bay we have a band of ferruginous sand rock and underlying sands, not exceeding 3 ft., then a band of limestone "1 ft. 6in.," overlying 12 ft. of clays, which again rest on some 15 ft. of sands. Below the Potamomya clays in Headon Hill we have the Great Limestone 20 to 30 ft. thick, usually resting on sands of variable thickness, 6 to 12 ft., though separated in places by a foot of green clay. In both we have an aggregate of nearly 50 ft. of strata—a great thickness of fresh-water clays above, and a good thickness of fresh-water sands below. With the example of the Osborne Limestone so close at hand, it seems not unnatural to conclude that the Great Limestone (the singular factor in the correlation) thinned out speedily to the N., the clay and sands beneath increasing correspondingly. We must point out that Prof. Blake, in arguing otherwise, comes to contradictory conclusions, first stating[1] that "the Cerithium and Oyster beds of Colwell Bay occupy the place of ferruginous sands below the Headon Hill Limestone," and, finally,[2] that the "Headon Hill Limestone becomes the fresh-water representative of part of the marine Brockenhurst" (*i.e.* Colwell Bay) "series, and *thus becomes doubly anomalous.*" The italics are ours. A limestone intercalation over a limited area in an estuary is a recognized *vera causa*, but a depression in the N., which admits the sea over that part of the area, while 24 ft. of fresh-water limestone are being formed within half a mile in the shallows of the S.—where the sea too had had access not long before—is almost inconceivable.

The two "Upper Headon" Series occur in localities situated at a distance of about a mile and a half. But the two brackish-marine series approach within half a mile. It is no longer a comparison of Colwell Bay and Headon Hill, but of the northern and southern boundaries of Totland Bay. For the brackish-marine of Colwell Bay can without a shadow of doubt be followed by the eye continuing into that of Warden Point and Warden Cliff, cropping out on the top of the cliff just N. of Weston Chine. The question then narrows to this. Does the Totland brackish-marine of Warden Cliff agree in detail with that of Headon Hill just opposite so closely that we must suppose them to have been continuous? For if so, then the Colwell Bay brackish-marine, continuous with that of the Warden Cliff, must have been of the same age with that of Headon Hill, by the least equivocal of all geological tests, continuity of strata. Messrs. Keeping and Tawney assert that the sequence is identical in Warden Cliff and the N.E. corner of Headon Hill. The thickness they obtain for the series—with a definite *C. ventricosum* band above and a definite fresh-water limestone below in both cases—is in the N. 34½ ft., in the S. 31 ft. 9 in. to 33 ft. And they state, moreover, that the lithological and palæontological details of these two near sections were so far identical that repetition was useless. Owing to the state of the Headon Hill beds above mentioned during our stay, we cannot offer any fresh evidence on this point, though we found the general succession at Warden Point much like that of the S.W. of Headon Hill, with *Ostrœa velata* most abundant in a middle zone. We took the height above the sea of this oyster band at four points.

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[1] *op. cit.* p. 157.

[2] *op. cit.* p. 160.

| | | |
|---|---|---|
| Totland brackish-marine | At Warden Point under the fort ........ | 55 ft. |
| | In the brickyard near Totland Hotel .... | 70 ft. |
| Headon brackish-marine | Below the cottage at N.E. corner ........ | 94 ft. |
| | N. of Alum Bay at S.W. corner ........ | 128 ft. |

These measurements are strongly in favour of the continuity of the series, for the anticlinal is grossly exaggerated in Forbes's diagram.

The correspondences continue as we proceed downwards. Prof. Blake admits fully that the How Ledge Limestone was continuous with that at the top of the Lower Headon in Headon Hill. They agree in thickness, in appearance, with abundance of *Limnea* and scarcity of *Planorbis*. The How Ledge Limestone is continuous from the Ledge nearly to Weston Chine; the Lower Headon Limestone is continuous throughout the Hill; there is but this hiatus for half a mile caused by palpable denudation. As to the beds below this Limestone, there is no discrepancy in published evidence. Prof. Blake admits that the succession at Headon Hill (noted at some point on the W. face) "is perfectly in accordance with that at Totland Bay."[1] The details of Headon Hill agree essentially with the full section of the Totland Bay strata between Warden Point and Weston Chine, published by Messrs Keeping and Tawney.[2]

It may be said then, in support of the Survey view, that we traverse the same succession of strata as we climb Headon Hill from the shore, and as we walk from Widdick Chine to Cliff End, that there is no break or unconformity in either series, that where the beds of the two series are adjacent, certain are practically identical, and that divergences in what are claimed as corresponding beds are found when they are compared at greater distances, that the conspicuous Bembridge Limestone and Osborne Marls cap both series above, and that the correspondences both in general order and in detail, are such as to bring possible errors of correlation between very narrow limits.

We now turn to the palæontological evidence of the brackish-marine strata. Such evidence is naturally not considered by Prof.

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[1] Proc. Geol. Assoc. vol. vii. p. 158.

[2] *op. cit.* p. 98.

Blake, although it is decisive,[1] as it is impossible, until long acquaintance with the ground makes the exact position of the smaller zones on all parts of the coast familiar, to make anything like an exhaustive collection. We cannot adduce lists of the completeness of those of Messrs. Keeping and Tawney,[2] although we spent much time and pains to find as many forms as might be, but in some particulars our evidence is in positive confirmation of their observations. There are three lines of argument adopted by the authors at issue in correlating or separating these two brackish-marine series. First, there is a comparison of the life-zones of the two series. It is claimed by the defenders of the Survey that in both are five beds, characterized in descending order by certain lithological characters and respective predominance of *Cerithium ventricosum*, Sow.; *Ostrœa velata*, Wood; *Cytherea incrassata*, Sow.; *Trigonocœlia deltoidea*, Lam.; and *Neritina concava*, Sow. We have noted in our own section the brackish forms above and below, and the distinct oyster-bed about the middle. Dr. Wright also notices the *Neritina* bed. Secondly, the aggregate of forms found at Colwell Bay is compared with the aggregate of forms at Headon Hill. Messrs. Keeping and Tawney's lists of the commoner fossils give 55 forms from the former, and 54 from the latter, and 51 occur in both. We found, in addition, *Cerithium duplex* (Sow.) in both localities, which gives out of 55 commoner species 52 occurring in both series. In the complete fauna as known Dec. 1880, Messrs. Keeping and Tawney, after a careful re-examination of the Edwards Collection, reckon 74 per cent. of the Colwell Bay marine species as having been found at Headon Hill. This may point to more purely marine conditions in the N., agreeing with the presence of the coral fauna at Brockenhurst, as already admitted by Dr. Duncan,[3] who quotes other evidence as to the identity of fossils at Colwell Bay and Headon Hill. Thirdly, the different distribution of the two *Cerithia* (*C. ventricosum* and *C. concavum*) is made a crucial point. We found both species in the Colwell Bay beds, as did Messrs. Keeping and Tawney. Our specimens of *C. concavum* occurred a little below the oyster-bed, between Colwell Chine and Warden Point, a position in which the shell was noted by us N. of Alum Bay Chine. They found them in "the richest portion of the Venus-bed." Its absence from Colwell Bay is therefore disproved.

The result of our observations, then, is to convince us that on many crucial points the older views are correct, and that the brackish-marine of Colwell and Totland Bays cannot be continuous with supposed marine beds above the Great Limestone, nor with the Great Limestone itself, nor with the fresh-water sands (containing *Unio Solandri*, *Paludina*, etc.) below the Limestone, but corresponds in position, lithology, and fossil contents, with the brackish-marine of Headon Hill, and that it is restricted to this correspondence moreover by the parallel correspondences of the beds below and above it.

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[1] *op. cit.* p. 156, note.

[2] *op. cit.* p. 105.

[3] Duncan, Mon. Pal. Soc. pt. 1, p. 40.

## II.—NOTICE OF A PTERASPIDEAN CEPHALIC PLATE FROM THE DEVONIAN BEDS OF GEROLSTEIN IN THE EIFEL.

By JOHN EDWARD LEE, F.S.A., F.G.S.

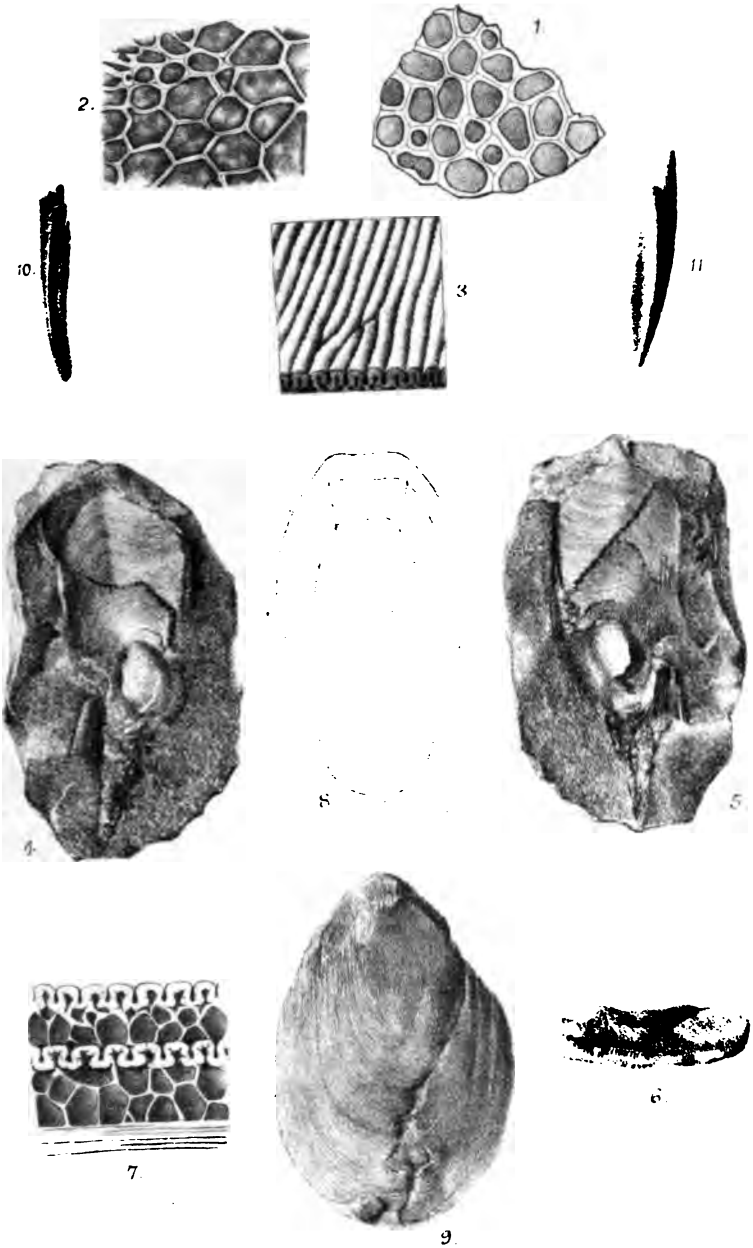
(PLATE III.)

LAST Autumn, on our way to St. Cassian and the Dolomites, we remained for two or three days in the Eifel. The little town of Gerolstein is well known to all geologists. Mr. Winter, one of the inhabitants, who pays considerable attention to the natural history of the place, was kind enough to present me with a nodule which, though apparently it is very insignificant, yet, on further examination, seems of great interest; it contains, in fact, part of the scale of a Pteraspidean. Any one who has worked amongst the Old Red Sandstone fishes of Monmouthshire and Herefordshire will at once recognize many of the characteristics of the Pteraspidean scales.

There are, however, some peculiarities in the scale found in this apparently insignificant specimen, which are probably worth placing on record until better specimens are found, which should at once be placed in the hands of an expert; there may possibly be characters sufficiently different from the usual structure to form a new genus.

It is well known that the scute or dorsal plate of the Pteraspideans, as yet known, is composed of three layers; the lower one is called by Professors Huxley and Lankester the nacreous layer; it does not show *much* organization under the microscope, but still a few vessels may be distinctly seen passing through it. Above this is what may be called a layer of "honeycomb" structure, the walls of which, when highly magnified, are found to be composed of a large number of very thin plates. This character is very well seen in sections from the Monmouthshire Pteraspideans. A small portion of one is given (Plate III. Fig. 1). The Looe and Polperro specimens (*Scaphaspis*) are very nearly the same, but the structure of the walls is not so apparent; probably this difference is caused by greater mineralization. Fig. 2 is part of a sketch of one of these sections from Polperro. These two sections are merely explanatory of the normal structure of the middle or honeycomb layer. The upper, or what has hitherto been considered the outer, layer is black in colour, and made up chiefly of parallel lines, almost exactly like those of the corrugated sheet iron roofs now in common use. Fig. 3 will give an idea of a small portion of this coat from a specimen from Polperro.

In the specimen under consideration from the Eifel (Plate III. Figs. 4 and 5) there appear to be some peculiarities. In the first place, the nacreous layer seems to be absent, and though, as has been observed by a leading palæontologist, this may be accounted for by supposing that it has perished, there is still a greater peculiarity which can hardly be explained in this manner; for apparently the black corrugated portion is not on the outside, but (at least in one instance) lies between two of the honeycomb layers. Fig. 6 is a side-view, and Fig. 7 is a much magnified view of what appears to show that in this Eifel scale there are two if not three "honey-



G. M. Woodward del. et lith.
West Newman & Co. imp.

*Pteraspidean plates from the Eifel & from British Localities.*

comb" layers separated by black lined layers. It will be seen that though in almost every case the black corrugated layer has disappeared, yet it has left its marks upon the surface of the corrugated layer. My friend Mr. Pengelly, who, in fact, knows more of the Polperro *Pteraspideans* than any one else, before he saw the specimen, suggested that the repetition of the honeycomb layer might possibly be accounted for by one scale having been washed into another, so that, in fact, the specimen consisted of two scales instead of one; but, if so, what has become of the nacreous layer? and in fact, a careful examination of the portion drawn will probably convince the observer that it consists of *one* and not of *two scales*. It may possibly be said that the scale has been broken up and one part as it were faulted up and pushed over another part; but though there may be some probability in this explanation, yet it seems to me that, after a careful examination of the specimen, this idea will be abandoned. Figs. 4 and 5 give a sketch of the general appearance of the two sides of the nodule.

It may be an abortive or "monster" scale, and so not entitled to much consideration; but still it is as well to place such abnormal structures on record.

As the specimen under consideration is the only one as yet discovered at Gerolstein, it has not been thought desirable to deteriorate it by repeated attempts to make a section of the "honeycomb" structure. It may be well to mention that on account of the tendency of this structure to disintegrate under the operation of grinding, it is extremely difficult to obtain microscopic sections of it. The section of which a portion is drawn, Fig. 1, was only obtained after fully twenty failures. Not more than three or four were attempted from this Eifel nodule, and the thing was then abandoned, lest the specimen should be spoiled, which probably would have been the case, had a larger number of sections been tried.

NOTE.—Since writing the above, Mr. Pengelly has kindly allowed me to see his splendid specimen from Looe. My first impression was that of extreme regret that there is no published drawing of such a beautiful specimen, and I must confess that Mr. Pengelly's explanation of the repeated "honeycomb" layers seems perfectly correct *as far as his specimen is concerned,* for there is not only a very thin layer of slate between these layers, but in one place there is also the indication, if not more, of the nacreous layer; but the case seems very different in the Gerolstein specimen, as neither the separating slate nor the nacreous layer seems at all visible in it.—J. E. L.

## EXPLANATION OF PLATE III.

FIG. 1. Highly magnified section of *Scaphaspis* (*Pteraspis*) *Lewisii*, Old Red Sandstone, Maindec, Monmouthshire, showing honeycomb structure. Magnified 20 times.

,, 2. A similar section of *Scaphaspis cornubicus*, Devonian, Polperro, Cornwall. Magnified 6 times.

,, 3. Magnified view of the corrugated surface layer of *Sc. cornubicus*, Polperro.

FIG. 4 & 5. View of two sides of nodule from Devonian, Gerolstein, containing plate of *Scaphaspis*, sp. Nat. size.
,, 6. Side view of same, showing the several layers of which the scute seems to be composed. Nat. size.
,, 7. Highly magnified section of the same, showing repeated layers of shell-structure.
,, 8. Outline of shield of *Scaphaspis* (restored).
,, 9. Rostral plate of *Pteraspis*, Old Red Sandstone, Stow Hill Road, Newport, Monmouthshire (magnified three times).
,, 10 & 11. Dorsal spines of cephalic shield of *Cephalaspis*, Devonian, Polperro, Cornwall.

(The above are all preserved in the author's Cabinet; Villa Syracusa, Torquay, South Devon.)

## III.—SUPPLEMENT TO A CHAPTER IN THE HISTORY OF METEORITES.

By WALTER FLIGHT. D.Sc., F.G.S.

(*Continued from* p. 69.)

### 1875. March 31st, between 3 and 4 p.m.—Zsadány, Temesvàr, the Banat, Hungary.[1]

No luminous meteor appears to have been observed at the time these stones fell; the day was bright and sunny and the sky cloudless. A sound as of platoon-firing was heard, and a small shower of black stones descended, some within the area of the village of Zsadány in the courtyards of the inhabitants, others in the open fields. They did not fall together, but at slight intervals, which appear to have been at least one-third of a minute. Some were picked up immediately they reached the ground, and were found to be *cold*. It may be mentioned here that the stones which fell at Dhurmsala, in India[2] (1860, July 4th), are stated to have been so cold that they could not be held in the hand.

Sixteen stones in all have been found; the largest, having the size of a goose's egg and weighing about 152 grammes, is preserved in the National Museum at Pest; the remainder have an average size of a walnut, and their aggregate weight is nearly 400 grammes. Memák has sent a preliminary report describing the seven largest stones, illustrated with photographs of the four most interesting masses, to the Hungarian Academy of Sciences. The investigation of this aërolite has been undertaken by Wartha and Krenner; the former will subject it to analysis, the latter examine its mineralogical characters.

I learn, from an obliging letter received from Prof. Szabó, that these meteorites have a coarse-grained texture, and are somewhat friable, and that they contain nickel-iron and scales of graphite.

Dr. Cohen, of Heidelberg, received some fragments of the stone from Dr. Babesin, and he has recently published a paper on the results of the physical and chemical examination of them.[1]

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[1] Egyetértés és Magyar Ujság, 23rd April, and June 16th, 1875.

[2] W. von Haidinger, *Sitzungsber. Akad. Wiss. Wien*, xlii. 305, xliv. 285. [It was a subject of frequent remark in conversation by Professor Brayley that the only foundation for this statement was a part of the native evidence collected on the occurrence of this stonefall, that the meteorite came "from the abode of snow"—a phrase which, in the native dialect, signifies a "northern direction," by a simple but direct allusion to the snow-topped summits of the Himalayas.—Professor Alexander Herschel.]

The crust of the stone has a brownish black colour, and is ⅙ to ¼ mm. in thickness; it has the appearance as though it had not been subjected to so intense a heat as that usually developed during the fall of a meteorite. The finely-grained light grey matrix encloses granules of magnetic pyrites (troilite?), granules and plates of nickel-iron, and numerous dark grey crystalline spherules, averaging ½ mm. in diameter; one little sphere had a breadth of 3½ mm. They have an excentric-radiate or contorted-radiate structure. A freshly broken surface of the stone is studded with these chondra, and they are easily removed from the matrix. As regards their mineralogical aspects, the spherules are found to be of two kinds. One consists of small prisms of a rhombic mineral, which has all the appearance of a variety of enstatite; others are found to possess all the properties of olivine. These two minerals also constitute the greater portion of the matrix. The augitic mineral occasionally contains opaque granules and colourless microlites, the olivine pores or cavities, some of which, the author states, appear to contain fluid. Metallic particles are rarely, if ever, found in the spherules themselves. An accessory mineral, transparent, pure, and with well-defined edges, is also to be found in the meteorite. It differs from the rhombic augite in exhibiting no cleavage fissures, from olivine by the smoothness of its polished exterior, and from both of them by exhibiting distinct pleochroism with absorption; one tone being colourless, the other pale red with a faint tinge of brown. It appears to be rhombic, and shows a close resemblance to a variety of hypersthene found by Cohen in a gabbro from South Africa. The Zsadány stone resembles those which fell on several different occasions at Lancé, Gopalpur, and Pultusk.

By treatment with acid a considerable quantity of the silicate was decomposed. The analysis of the portions thus separated gave the following numbers:—

| | Soluble Portion. | Insoluble Portion. |
|---|---|---|
| Silicic acid | 44·56 | 56·71 |
| Alumina | trace | 2·32 |
| Iron oxide | 17·54 | 13·21 |
| Lime | trace | 1·77 |
| Magnesia | 37·90 | 25·99 |
| | 100·00 | 100·00 |

The stone, therefore, appears to consist to the extent of three-fourths of a bronzite, the remaining fourth being an olivine, in which the equivalents of MgO : FeO are as 3·89 : 1, or approximately that which is often met with in meteoric olivines.

## 1875, April 14th, 0·30 a.m.—Haddon, Grenville Co., Victoria, Australia.[2]

A very brilliant meteor appeared from a bank of cloud about 20°

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[1] E. Cohen, *Verhandl. Naturhis. Med. Vereins zu Heidelberg*, 1878, II. Heft 2.

[2] *The Illustrated Australian News*, May 17, 1875, p. 68.

above the N.W. horizon; it became elongated and pear-shaped as it traversed the heavens from W. to E., attaining an altitude of 50° on passing the zenith, where the nucleus appeared to break up and roll on in misshapen spheres of various sizes. On reaching a point within 20° of the N.E. horizon, the light became more intense and then the meteor disappeared. Eight or ten seconds later, reverberations as of thunder were distinctly heard. An eye-witness stationed at Haddon thought he saw matter fall near him, and the next day, found a lump of melted matter, light in weight and of a nearly black colour, a portion being "a yellowish-brown substance like cinders from iron-smelting," as well as two fragments that were black, like coke, and a smaller fragment of a yellow hue. This great meteor, of which an engraving is given in *The Illustrated Australian News*, was, it appears, observed in several parts of the country; but no other accounts of it indicating either the extent or position of its real course have yet been received.

### 1875, August 16th (about noon).—Feid-Chair, Cercle de la Calle, Constantine.[1]

This meteorite fell about midday at a spot named Feid-Chair, about 30 kilomètres from La Calle, the descent being attended with the accustomed luminous appearance. It weighs about 380 grammes; all search to discover other stones has proved of no avail. The stone has a black crust and a grey interior, in which particles of nickel-iron and troilite are imbedded. Spherules are recognized, but the matrix likewise exhibits a brecciated structure; grains of a dull black hue are also distributed through the mass. The siliceous portion acts on polarized light. The enclosed crystals are too small to allow of their form being recognized. This portion of the stone is acted upon by acid, and appears to consist of a mixture of olivine and enstatite. The Feid-Chair meteorite closely resembles the stones which fell at La Baffe, Dép. des Vosges (1822, September 13th), Heredia, Costa Rica (1857, April 1st), Canellas, near Barcelona (1861, May 14th), and Khetree, Rajpootana, India (1867, January 19th). This is the third occasion within the space of twelve years that meteorites have been seen to fall in Algiers and have been preserved.

### 1875, September 14th, 4 p.m.—Supino, circ. Frosinone, Rome.

The asserted fall of an aërolite on this date, recorded in former pages, and again as an authentic stonefall in the "Monthly Notices of the Royal Astronomical Society" (vol. xxxvii. pp. 205–6), is entirely refuted by a letter from Padre Secchi, in the latter volume of the "Monthly Notices" (p. 365), in which the real circumstances of the supposed meteor and stonefall are related and described. A flash of lightning which occurred in the public square of Supino struck a neighbouring house with sufficient violence to dislodge a stone from the roof, without doing any more material damage to the house. The supposed "meteorite," which fell in the courtyard of the house, is identified by the Padre Secchi with the ordinary volcanic stones of the district, which is in the neighbourhood of an extinct volcano, and it probably lay (as it is customary to protect them against the force of the wind) upon the tiles of the roof until it was projected from its place by the lightning-stroke.

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[1] G. A. Daubrée, *Compt rend.* 1877, lxxxiv. 70.

### 1875, December 27th, 9 p.m.—Kansas.

I have to thank Mr. Irish, C.E., of Iowa City, for two cuttings from newspapers (the *Kansas Chief* of December 30th, and the *Kansas Evening Post* of December 29th) recording the fall of a detonating meteor of the above date. It traversed the heavens in a direction from N.W. to S.E., leaving a lurid streak in its wake. The whole heavens were lighted up, and "made all out of doors almost as light as full moonlight." The meteor was of the usual whitish-red colour, and when it exploded the fiery fragments were scattered in all directions. "Perhaps two minutes later, and after all appearance of the meteor had disappeared, the sound of the explosion came like the discharge of a heavy cannon; or rather one loud explosion, immediately followed by a lighter one like an echo. The explosion jarred houses and rattled windows. The size of the meteor and the terrible force of the explosion may be imagined from the fact that the distance was so great that it required about two minutes for the sound to reach the earth, and the concussion was so plainly felt and heard at that distance. The phenomenon was witnessed over a large extent of country." An observer, writing from Fort Leavenworth, states that it appeared to have its origin in the constellation Cassiopeia, and its course was due east. Mr. Irish states that he has made every effort to secure possession of the meteorites which must have fallen, but has been unsuccessful. The time of flight is estimated to have been from 12 to 15 seconds.

### 1875, December 27th, 9·20 p.m.—State of Missouri, U.S.A.

I am indebted to Mr. Irish, C.E., of Iowa City, for an interesting description of this detonating meteor, as well as for a map, on which he has traced its course. The point where it was first seen in the zenith is at Thayer, in Nebraska, near the borders of Kansas, and about 120 miles W. of the Missouri River. It was seen by him at Iowa City first as a small meteor, which rapidly became brighter, and was hidden from view when at an altitude of about 40° by a building; at this moment it gave out a very brilliant quivering flash of light, which illuminated the whole heavens. It appears from Mr. Irish's map to have been seen over a wide area, from Stillwater in Minnesota on the north, to Buffalo in Missouri on the south, and as far west as the shores of Lake Michigan. Near the termination of the flight sounds were heard: over Archer, in Nebraska, a rushing roaring sound, as of a mighty wind, was noticed; at St. Joseph, in Missouri, the first distinct explosion was remarked, and between that town and Livingstone Co. frequent and very heavy detonations occurred. In the last-mentioned district, and at places as far as 60 miles distant, numerous red fragments were seen to fall. He says, "I have had several persons looking for the meteorites where the fall must have taken place; but the whole district is covered with dense forest, and is mountainous and broken, and the ground was very soft from the long-continued rains preceding the fall, so that no fragments have been found. All the observers of the final explosion agree that the great bulk of the material was thrown upward and backward upon the course of the meteor, as the arrow-pointed dots in my sketch indicate. The luminous appearance continued in sight for 15 minutes."

### Found 1875 (?).—Red River, northward of Young Co., Texas.[1]

There is preserved in the State collections at Austin a mass of meteoric iron weighing 315 lbs., which is said to have been found on the head waters of the Red River, northward of Young County.

### 1875. Butler, Bates Co., Missouri.[2]

This iron has already been described by Broadhead[3] and Smith,[4] the latter finding it remarkable for the very large and regular Wiedmannstättian figures which it displays. A specimen, weighing 1 kilog. 334 grammes, acquired by the Vienna Collection from Dr. L. Smith, was found to have three etched surfaces nearly perpendicular to each other. It was noticed that the greater part of the iron had an even dull appearance, but in this lustreless iron grey part lay numerous, in part individual, in part grouped together, lamellæ, of which four differently directed systems appear on the sections. The lamellæ together form a skeleton—or octohedral skeleton—just as in Tschermak's Schematic, fig. 5,[5] the crystal-structure of iron indicates a hexahedral skeleton.

The ground-mass. though lustreless and structureless, shows a peculiar play of light, to which later reference will be made; its hardness is remarkably low, a little below 4, being distinctly scratched by fluorite. The system of lamellæ are finely granular and in several respects show the greatest resemblance with the ground-mass (hardness, etc.); only in a few broader places a feebly indicated granular structure shows itself, and recalls the balk iron of other irons. The lamellæ are covered with band-iron (tänite) which is recognized by its high lustre and pale isabel-yellow colour; they are very small, the nucleus and the two covers being in most cases not more than $\frac{1}{80}$ of a millimètre, and the length usually 15 to 20 mm. (some are 30 mm.). Where lamellæ differently directed come together, one system is usually developed quite uninjured;

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[1] S. B. Buckley, "Second Annual Report of the Geological and Agricultural Survey of Texas," Houston, Texas, 1876.

[2] A. Brezina, *Sitzber. Akad. Wiss.* 1880, lxxxii. Oct. Heft.

[3] Broadhead. *Amer. Journ. Sc.* [3], x. 401.

[4] Smith. *Amer. Journ. Sc.* [3], xiii. 211.

[5] Tschermak. *Sitzber. Akad. Wiss.* lxx. 1874, 443.

sometimes, though rarely, nucleus lies on nucleus and cover on cover, in proof of the simultaneous origin of the system.

From the main strikings of the four systems, not alone parallel, but small plates lying irregularly overlaid occur in the ground-mass, and to these is due the peculiar play of light of that part of the iron. Troilite occurs in rounded or lenticular masses, some 2 ctm. in diameter; but none is found in the lamellæ systems.

The largest of the sections does not vary very much (about 13°) from the position of a leucitobedral face; three distinctly marked lamellæ systems cross it at angles of 70°, 61° and 49°. For the face (533) the corresponding values are:—

$$65^\circ{\cdot}4,\ 0^\circ,\ 65^\circ{\cdot}4,\ 49.^\circ2\ \ (0^\circ + 65^\circ{\cdot}4 = 65^\circ{\cdot}4)$$

The drawings of these sections are to be published later on.

### 1876, January 5th, 10·30 p.m.—Iowa and Missouri.

This meteor, according to Mr. Irish's letter and accompanying map, was witnessed over an area extending from Cass, in Iowa, to Grundy, in Missouri. It appeared to descend almost perpendicularly, and was a very brilliant meteor, and a very noisy one also. A series of reports, twenty-two in number, were heard during its transit from Cass to Grundy. The rumbling thunder of its artillery, together with its flashes of brilliant light, brought people from their beds with an apprehension that the great Civil War had broken out afresh. Its time of flight over the area indicated was not more than five seconds, and the light it emitted is said to have equalled that of noonday. None of the meteorites which must have fallen have been found, for the reasons already referred to when speaking of the detonating meteor of December 27th.

### 1876, January 31st, 5·30 p.m.—Louisville, Kentucky.

Dr. Lawrence Smith, of Louisville, observed a magnificent meteor traversing the heavens on the afternoon of the above day. He first saw it at an altitude of about 60° above the horizon, and it disappeared from view behind some houses at an elevation of about 20°. Its direction appears to have been from N.W. to S.E., and the angular magnitude about one-sixth that of the disk of the moon. It was seen over an area 120 miles in diameter. A number of observers witnessed an explosion which took place when the meteor was about 10° above the horizon; all the fragments disappeared instantly, except the largest, which also became invisible before it reached the horizon. One or two of the eye-witnesses think they noticed a whizzing noise, and at the time of bursting heard the explosion. No fragments of a meteorite have yet been met with; but it is the opinion of Dr. Smith that they fell about the range of the Cumberland Mountains in Kentucky, or in the north-east of Tennessee.

*(To be continued in our next Number.)*

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## IV.—NOTES ON THE VERTEBRATA OF THE PRE-GLACIAL FOREST BED SERIES OF THE EAST OF ENGLAND.

By E. T. NEWTON, F.G.S.

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### PART VII.—PISCES. (CONCLUSION.)

THE occurrence of Fish-remains among the "Forest Bed" Vertebrata attracted the attention of some of the earlier writers on Norfolk Geology; but it is only within the last few years that any of these fish have been specifically determined. Mr. A. Bell in the Proceed. of the Geol. Assoc. 1871, included the *Pike* and *Perch* in his list of "Forest Bed" Vertebrata, and the same two species are given by Mr. A. Savin in the Proceed. of the Norwich Geol. Soc. for 1878, p. 27. The fish mentioned by Sir C. Lyell from Mundesley (Lond. and Edinb. Phil. Mag. ser. 3, vol. xvi. p. 345, 1840) were from the Post-Glacial River Bed. A Sturgeon plate in the King Collection in the Museum of Practical Geology, has for several years borne on the label "*Accipenser latirostris.*" Prof. W. Boyd Dawkins has entered it in his MS. catalogue of this collection as "*Acipenser*"; but I am not aware that the occurrence of the genus in the "Forest Bed" has hitherto been published.

A large number of fish teeth, scales, and bones have been obtained within the last few years by Mr. A. Savin and my colleagues Messrs. J. H. Blake and C. Reid, and among these a number of new forms have been determined; so that we are now in a position to record seventeen species as occurring in these deposits; some of which are now for the first time known in the fossil state.

*Perca fluviatilis.*—This species, hitherto known in the "Forest Bed" by scales only, is now represented by several other characteristic parts, which have been obtained from the Freshwater Bed at West Runton and elsewhere.

*Acerina vulgaris?*—A single small otolith from the West Runton Freshwater Bed, agrees so closely with that of the common percoid fish, known as the Ruff, that it is with some little doubt referred to that species.

*Platax Woodwardi.*—The remarkable bones which have been called "Butterfly-bones," and are so well known to collectors of Norwich Crag fossils, have been found in some abundance at different horizons in the "Forest Bed Series," and so also have the enlarged interspinous bones which were included by M. Agassiz in this species.

*Esox lucius.*—Dentary bones, isolated teeth and other fragments undoubtedly belonging to this species are, perhaps, more frequently met with in the "Forest Bed" than any other remains. They chiefly indicate fish of moderate size, but occasionally large bones are found. The remains of this species are known from almost all horizons of the series and at numerous localities.

*Barbus vulgaris?*—Two specimens, in Mr. Savin's collection, of pharyngeal teeth and parts of their supporting bones, agree better with this species than with any other; their chief peculiarity being their cylindrical form and the backward direction of the curved crown. Both these specimens were obtained from the Freshwater Bed at West Runton.

*Leuciscus cephalus?*—A pharyngeal bone with several teeth, preserved in the Green Collection at the Natural History Branch of the British Museum, Cromwell Road, there is little doubt, belongs to this species; but as it was obtained from Ostend, there is some question as to whether its true horizon is not really much above the Forest Bed.

*Leuciscus rutilus.*—Three or four nearly perfect pharyngeal bones, but without teeth, and a large number of isolated teeth, are referable to this species. Most of them are from the West Runton Freshwater Bed, and are in Mr. Savin's collection at Cromer.

*Leuciscus erythrophthalmus.*—Among the numerous isolated teeth referable to the genus *Leuciscus* there are several which are believed to belong to this species, but there is one in the Museum of Practical Geology from the West Runton Freshwater Bed, which is held to be undoubted evidence of its occurrence.

*Abramis brama.*—Two unworn teeth from West Runton present the peculiar groove under the apex which is seen in the pharyngeal teeth of the Bream, and so far as I know in these alone.

*Tinca vulgaris.*—Several short teeth with broad crowns and small pedicles evidently belong to this species; they are all from the West Runton Freshwater Bed, and are now in Mr. Savin's collection and in the Museum of Practical Geology.

*Gadus morrhua.*—This species is represented by portions of jaws from the "Forest Bed" of several localities, and specimens are to be seen in Mr. Savin's collection, and in the British and Jermyn Street Museums.

*Gadus pollachius.*—Two portions of otoliths from the Weybourne Crag at Runton are believed to belong to this species. Examples of two other forms of otoliths have also been found which have not yet been determined; although probably belonging to the same genus, they certainly do not belong to either of the species known from the Forest Bed.

*Galeus canis.*—This genus and species is represented by a single but characteristic tooth from the Weybourne Crag of Runton.

*Acanthias vulgaris.*—This form is also represented by a single tooth, from the Weybourne Crag of Runton, and like the last is now for the first time known in the fossil state.

*Raja batis.*—Numerous teeth from the Weybourne Crag at Runton evidently belong to one of the Skates; and several can be identified with the *Raja batis.*

*Raja clavata?*—Several teeth obtained with the last species agree closely with the two forms of teeth found in the male and female *Thornback* and are with some reserve placed in that species.

Examples of all the above "Forest Bed" Fish, with the exception of *Barbus vulgaris* and *Leuciscus cephalus,* are to be seen in the Museum of Practical Geology.

LIST OF FISHES FROM THE "FOREST BED SERIES."
(Those marked with an asterisk* are new to the "Forest Bed Series.")

_Perca fluviatilis_, Linn.
*_Acerina vulgaris ?_ Cuv.
*_Platax Woodwardi_, Ag.
_Esox lucius_, Linn.
*_Barbus vulgaris ?_ Flem.
*_Leuciscus cephalus ?_ Linn.
* ——— _rutilus_, Linn.
* ——— _erythrophthalmus_, Linn.
*_Abramis brama_, Linn.
*_Tinca vulgaris_, Cuv.
*_Gadus morrhua_, Linn.
* —— _pollachius ?_ Linn.
_Acipenser_, sp.
*_Galeus canis_, Linn.
*_Acanthias vulgaris_, Risso.
*_Raja batis._
_Raja clavata._

In bringing these notes on the "Forest Bed Vertebrata" to a close, I desire to offer my best thanks to the gentlemen in charge of public collections and those possessing private ones, who have so freely placed their specimens at my disposal, thus enabling me to compare them and to accomplish a task which would otherwise have been impossible.

It is hoped that the memoir, of which these notes have been an epitome, will now shortly be published by H.M. Geological Survey, and will be found useful for future workers in this field. Much still remains to be done, and doubtless new material will be brought to light, which will enable us to trace more clearly than is even yet possible, the changes of life which must have taken place between the early Pliocene times and the Glacial and Post-Glacial periods.

## V.—THE TWT HILL CONGLOMERATE AND THE BASE OF THE CAMBRIAN.

By R. D. ROBERTS, M.A., D.Sc. (Lond.), F.G.S., Clare College, Cambridge.

A FEW words of explanation are required to enable those not familiar with the Carnarvon district fully to appreciate the importance of Prof. Bonney's confirmation[1] of the view respecting the age of the Twt Hill conglomerate first put forward by Prof. Hughes, and afterwards advocated by myself.[2] The controversy possesses a general interest, apart from the fact that the stratigraphical position of a certain bed is now fixed, inasmuch as it shows how cautious it is needful to be in dealing with these ancient rocks without the most thorough and careful mapping of the whole area.

In February, 1879, Prof. Bonney read his paper on "The Metamorphic Series between Twt Hill and Port Dinorwic" before the Geological Society, and described the conglomerate in the Twt Hill quarry. "The rock," he says, "exposed on the summit of Twt Hill is at first sight like a coarse granite, which, however, is almost without a micaceous constituent." "The lowest rock exposed in the Twt Hill quarry is of the same type as that at Twt Hill. Above it comes a bed with a similar matrix, containing pebbles in the upper part, then a band of coarser conglomerate, the pebbles being often full an inch in length. To this succeeds a band of finer conglomerate, then coarser, and lastly another of finer, *passing up*

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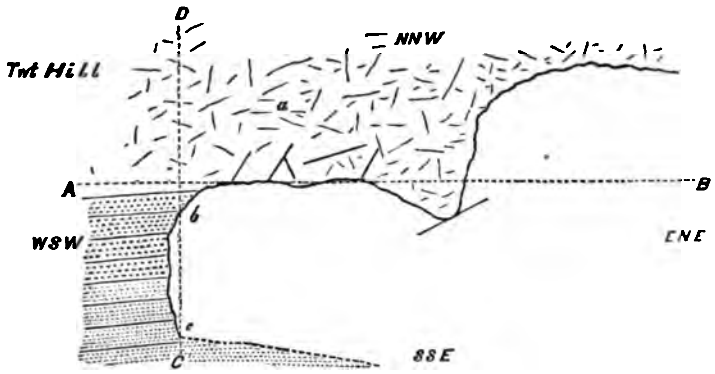
[1] See GEOL. MAG. Jan. 1882, p. 18.

[2] See GEOL. MAG. Vol. VIII. Dec. II. p. 194 and p. 439.

*into a rock which has some resemblance to the bottom rock.*" (The italics are not Prof. Bonney's.)

In the discussion which followed, Prof. Hughes pointed out, as the result of his own mapping of the district, that Prof. Bonney had misapprehended the direction of the dip, having been misled by the very deceptive appearance of the surface of the quarry, and had mistaken the patches of conglomerate sticking to the face of the quarry for alternating beds of conglomerate and granitoidite. He further stated that the conglomerate really dipped away from Twt Hill, passed up into brown sandstones on the S.S.E. rim of the quarry, and was the basement bed of the Cambrian, resting upon the Pre-Cambrian granitoid axis, as indicated in his section drawn across the same ridge nearer Bangor (Q. J. G. S. Dec. 5th, 1877). To make the matter perfectly clear, I give a ground-plan of the quarry (Fig. 1). Prof. Bonney's section, to which the description above quoted applies, was taken along the line *A B*. The section (Fig. 2) is a copy of Prof. Bonney's, given in Q. J. G. S. vol. xxxv. p. 321, and is a reduced representation of the diagram exhibited at

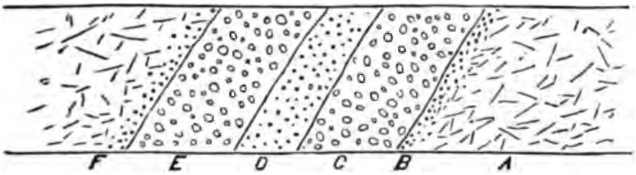
FIG. 1. (Ground Plan of Twt Hill Quarry.)



*a*. Granitoid rock.
*b*. Twt Hill Quartz conglomerate.
*c*. Brown sandstone.

*A B*. Line of Prof. Bonney's section.
*C D*. Line of Prof. Hughes' section.

FIG. 2. Prof. Bonney's section. (*A* to *B*. Ground Plan.)

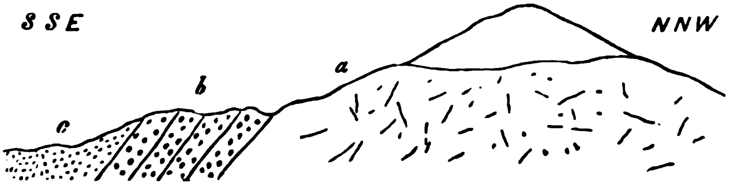


*A*. Granitoid rock.
*B*. Same becoming pebbly.
*C*. Coarse conglomerate.
*D*. Fine conglomerate.
*E*. Coarse conglomerate.
*F*. Finer conglomerate, in parts more like *B* and *A*.

the meeting of the Society. It will be in the recollection of all who were present at the meeting of the Society that in the original diagram Twt Hill was shown on the left, the beds dipping towards it. This indication of the direction was omitted in the published section, which section did, however, represent the general appearance of the face of the quarry with the oblique patches of conglomerate inclined along the surface of the granitoidite towards Twt Hill. After this direction of dip was given up it was still held by some that the trend of the rocks was across the ridge of the Bangor-Carnarvon range, until in the footnote to a paper (GEOL. MAG. Vol. VII. p. 300) Prof. Bonney stated that he had, as the result of subsequent examination, inferred that the trend of the beds in question corresponded more nearly, than he was formerly inclined to believe, with the line of the ridges, and that the Careg Goch grits, which he had believed dipped towards Twt Hill so as to pass under the Twt Hill conglomerate, might not in reality be at a lower horizon than that conglomerate. Now, however, he is so far persuaded that these grits are the same as the Twt Hill conglomerate, that, from having found felsite fragments in them, he is prepared to admit that the Twt Hill conglomerate is not a part of the granitoidite series. It might not be apparent to those who have not the map before them that the grits referred to as near the C of Cefn Cynryg are the same as those previously described as the Careg Goch grits, which are quarried within a stone's throw of the farm of that name, Cefn Cynryg farm being on different beds away to the south-east. Furthermore, the italicized portions above quoted render it perfectly clear that Prof. Bonney's section was taken along the line *A B*, since, in the section seen along *C D*, the conglomerate passes up into a sandstone, and not into any rock which could be spoken of as having "some resemblance to the bottom rock," *i.e.* to the granitoidite. The W.S.W. side of the quarry has always been much covered with brambles and débris, so that the succession was not obvious at first sight, and the patches of conglomerate clinging to the face of the granitoidite in irregularly oblique bands might easily appear, at a little distance, to be interstratified with it.

Prof. Hughes's section (Fig. 3), which represents the real sequence of the beds, was along *C D*, and is given in his paper, Q. J. G. S. vol. xxxv. p. 683, containing the detailed stratigraphical evidence upon which his conclusions were based. The view of the Cambrian age of the conglomerate was strenuously opposed by Prof. Bonney

FIG. 3. Line of Prof. Hughes' section (*C* to *D*. See Ground Plan, Fig. 1).



upon the following grounds, as summarized by him in Geol. Mag. Jan. 1882 :—

1. His inability to detect any line of demarcation between the granitoid beds and the conglomerate.

2. The absence of felsite pebbles such as occur in the Cambrian conglomerate of the Bangor district.

3. Microscopical evidence—the greater metamorphism of the matrix of the Twt Hill conglomerate than is usual in the Cambrian conglomerate.

In my two short papers to this Magazine on this subject these points have been dealt with.

1. I examined with great care on several occasions the junction of the conglomerate and granitoidite in the Twt Hill quarry, and came eventually to the same conclusion as Professor Hughes and Mr. Tawney—the conclusion in which Professor Bonney now concurs—viz. that the conglomerate and granitoidite do not belong to the same series.

2. To meet Professor Bonney's argument founded upon the lithological dissimilarity of the Twt Hill and Bangor conglomerates, I pointed out that if in a neighbouring area, a precisely similar quartz conglomerate, *without felsite pebbles*, constituted the base of the Cambrian, it was at any rate conceivable that the Twt Hill conglomerate might be Cambrian, despite the absence from it of felsite pebbles. The inference that the Twt Hill conglomerate was not Cambrian because it contained no felsite pebbles, implied the major premiss: "Cambrian conglomerates always contain felsite pebbles." Professor Bonney's own words on this point are, "I have never yet seen a felsite pebble in this conglomerate, or detected a fragment under the microscope, *yet that rock abounds in every known exposure of the Cambrian conglomerate*."[1] (The italics are mine.) I denied Professor Bonney's major premiss on the ground that the Cambrian conglomerate of a part of Central Anglesea[2] consists like the Twt Hill conglomerate of quartz pebbles imbedded in a felspathic matrix. Professor Bonney is mistaken in supposing that I regarded a "felspathic matrix" as identical with "fragments of felsite"; my argument was of an entirely different nature: that I am sure is clear without further words. Professor Bonney's argument therefore against the Cambrian age of the Twt Hill conglomerate based upon the lithological dissimilarity of the Bangor and Twt Hill conglomerates has fallen to the ground, because his major premiss cannot be maintained.

3. Microscopical evidence was not neglected. I got sections made of several of the rocks, and referred to some of these in my papers, but the evidence thus obtained was not sufficient to solve the problem.

My reason for believing the Twt Hill conglomerate to be Cambrian is the stratigraphical evidence given in Prof. Hughes' papers, and verified in the field. Prof. Bonney now accepts that conclusion, because he has detected with the microscope felsite fragments in the grits at Cefn Cynryg. This is the grit of Careg Goch described by Prof. Hughes, and shown in his Map and sections. It must be carefully noted that these felsite fragments have not been detected in the Twt Hill conglomerate, but in the grit of Cefn Cynryg or Careg Goch.

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[1] See Geol. Mag. Dec. II. Vol. VII. p. 300.

[2] There is no question that these Anglesea conglomerates are Cambrian, for Prof. Hughes has mapped them over the whole area, and found them in some sections to be fossiliferous, and to pass up into fossiliferous sandstones.

This grit of Cefn Cynryg is four miles distant from the Twt Hill conglomerate, and the assumption of the identity of the beds obviously depends on stratigraphical evidence. A year and a half ago Prof. Bonney wrote of the Twt Hill conglomerate as follows:—"Even[1] if it were proved that this conglomerate were made up from the materials of the rock on which it rests, *I could not believe it to be of Cambrian age, because the microscope shows that its matrix and the finer bands intercalated with it are much more highly altered than is the case with the Cambrian rocks.*" (The italics are mine.) That statement is explicit, and indicates a perfectly definite and final opinion. He now writes[2]: "While repudiating Dr. Roberts' arguments, I admit the substantial correctness of his conclusions as regards the Twt Hill conglomerate," and further on adds: "It was trusting too much to my eyes in the field (though they were perhaps not less experienced than those of Dr. Roberts), and refusing to listen to certain doubts suggested by the microscope, which led me wrong, as it has done other observers; it was my microscope, and that alone, which set me right." Is not Prof. Bonney mistaken in this? It was his microscope which led him wrong, when it led him to the conclusion above quoted that the Twt Hill conglomerate could not possibly be of Cambrian age. The stratigraphical evidence, by leading him to infer that the strike of the rocks was different from that which he was first inclined to believe, has set him right by showing the possibility of regarding the Careg Goch grits near the C of Cefn Cynryg, and the Twt Hill conglomerate, as "a local development of the Cambrian conglomerate." It does not appear that the microscope has revealed anything new as to the structure of the Twt Hill conglomerate since the above italicized paragraph was written; it has merely shown that the Cefn Cynryg grit, four miles distant, contains felsite fragments, a fact which is scarcely of first-rate importance, seeing that the felsitic character of the Cambrian conglomerate at Llanddeiniolen, which has been identified with that at Careg Goch, has been known all along. I make no further comment. The points brought out in Prof. Hughes' papers on North Wales are now, therefore, thoroughly established, viz. that the succession of the Cambrian is as follows: (1) A basement conglomerate series, consisting sometimes of a quartz conglomerate, sometimes of a felsite conglomerate, and sometimes of quartz or felspathic grits, succeeded by (2) brown sandstones, often fossiliferous, and (3) black slates.

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[1] Geol. Mag. Dec. II. Vol. VII. p. 300.

[2] Geol. Mag. Dec. II. Vol. IX. p. 20.

## VI.—The Life and Work of Linnarsson.

By Prof. Chas. Lapworth, F.G.S.

(*Continued from page* 7.)

During the year 1871, in connexion with his duties upon the Geological Survey of Sweden, Linnarsson made a careful study of the Lower Palæozoic strata of Dalarne and Jemtland, publishing the fruits of his observations in the following year. Dalarne had been already most successfully investigated by Dr. Sven. Törnquist; but Linnarsson, familiar with details of the better known succession in Westrogothia, was enabled to throw much new light upon the crumpled and shattered strata of this region.

In Dalarne Linnarsson recognized:—

6. Leptena Limestone of Törnquist.
5. Upper Graptolite Shales.
4. Brachiopod Shales?
3. Trinucleus Shales.
2. Chasmops Limestone.
1. Orthoceras Limestone.

The Leptena Limestone of Törnquist he placed upon a higher horizon than the highest of the fossil-bearing zones of his native Westrogothia.

In Jemtland the Palæozoic strata appear to be locally metamorphosed, and the study of the succession is much more difficult. Nevertheless, Linnarsson was able to make out a similar succession consisting of the following members:—

8. Pentamerus Limestone.
7. (?)
6. Chasmops and Graptolite Beds.
5. Orthoceras Limestone.
4. Lower Graptolite Beds.
3. Ceratopyge Limestone?
2. Alum Shales.
1. Quartzite.

In the summer of 1872 Linnarsson, in order to gain information bearing upon the survey of the Swedish district embraced in the sheet Latorp, made a scientific tour through Central Europe and the Russian Baltic Provinces. In Copenhagen he studied the fine collection of Lower Palæozoic fossils collected by Prof. Johnstrup from the rocks of Bornholm. Thence he proceeded to Berlin, where he studied the assemblage of Palæozoic fossils collected by Beyrich and others from the erratic blocks of the drift of Northern Germany. His personal acquaintance with the Swedish succession led him to the conclusion that few of these erratics could have been brought from Southern Sweden, but that the vast majority had their sources in the islands of the central parts of the Baltic—Gothland, Öland, and Oesel. From Berlin Linnarsson proceeded to Dresden, examined the mineralogical collection of that city, and made a brief study of the geology of the neighbourhood under the guidance of the veteran Geinitz.

The Primordial region of Hof was next examined, and on the ground of the facies of the Trilobite fauna, Linnarsson reached the conclusion that its typical zones belonged rather to the second than to the first fauna of the Cambrian.

A delightful three weeks was next spent in the study of the classic rocks and fossils of Bohemia. Linnarsson was guided through the treasures of the magnificent collection at Prague by the illustrious Barrande himself, and accompanied by him to several of the more important geological localities in the field. His chief object was the collection of material for instituting a comparison between the Bohemian succession and that of his native land; and in this he was remarkably successful. His parallelism of the several formations of the Lower Palæozoic sequence of the two countries is by far the best yet instituted, and is likely to hold its own until Barrande himself makes known a more fully detailed description of the rocks and fossils of Bohemia. According to Linnarsson, Barrande's Primordial Zone of Skrey represents merely the lower half of the Swedish Cambrian—the upper or Olenus division being wanting in Bohemia. Etage D. represents the whole of the Swedish beds of the second fauna. The zones D 1—D 4 answer collectively to the Swedish formations Ceratopyge Limestone, Lower Graptolite Shales, Orthoceras Limestone and the Chasmops Limestone. Zone D 5 answers precisely to the Trinucleus Shales of Sweden, in position and fossil remains. The Brachiopod Schists of Sweden appear to have no equivalent in Bohemia, but the Upper Graptolite Schists correspond to the Graptolitic Shales at the base of Barrande's Etage E. E. 1. The Gothland Limestone stands generally in the place of the Bohemian Etage E. E. 1 and 2, but the Etages F. G. and H. of Barrande are utterly wanting in Scandinavia.

Linnarsson devoted special attention to the phenomena of the "Colonies" of Bohemia; and, judging from what he examined of the localities, he considered that such stratigraphical evidence as was apparent supported the views of Barrande himself.

From Bohemia Linnarsson travelled, by way of Breslau, to St. Petersburg and the Russian Baltic Provinces, and spent three weeks in the study of the Lower Palæozoic rocks and fossils of this region, in part under the guidance of Magister Schmidt. The material he collected furnished him with the means of instituting a parallel between the Lower Palæozoic rocks of Russia and Sweden, comparable with that worked out for Bohemia. According to Linnarsson's scheme, the deepest stratum visible in the Baltic Provinces—the Blaue Thon of Schmidt—answers generally to the Eophyton Sandstone or basal sandstone of Sweden. The well-known Unguliten Sandstein represents the Swedish Fucoid sandstone. The Paradoxides-bearing or Lower division of the Primordial zone has no recognizable representative in Russia; but the Thonschiefer mit Dictyonema of Schmidt is most distinctly the same zone as the Dictyonema shale or Upper Olenus beds of Sweden. The Ceratopyge Limestone and Lower Graptolite Schists of Scandinavia are apparently wanting in the Baltic Provinces, but the great Pleta or Vaginaten Limestone stands unquestionably in the place of the Swedish Orthoceras Limestone. Schmidt's Brandschiefer Linnarsson paralleled doubtfully with his own Chasmops Limestone and Middle Graptolite Schist, and the Bornholmsche Schist with the Swedish Leptena Limestone.

In the summer of 1873 Linnarsson mapped the Lower Palæozoic region of Nerike in Central Sweden, where he recognized a well-marked succession of Annelide-bearing sandstones lying unconformably upon the Archæan, and supporting a series of shales, representing the Alum Shales of the south in both divisions, and containing the typical Primordial fossils. Above these succeeded a limestone representative of the Orthoceras Limestone of the south, containing an abundance of the usual characteristic forms.

Before publishing these discoveries, Linnarsson made a tour of investigation through the Lower Palæozoic district of Scania, in Southern Sweden, already made familiar to geologists through the publications of Angelin and his predecessors, and more recently through the papers of Dr. Törnquist. This tour was prolific of the most brilliant results. Linnarsson discovered proofs of his own views of the succession at every stage, and was able to satisfy geologists of its identity with that already worked out by himself in Westrogothia. In addition, he ventured to parallel some of the formations with their British equivalents. His arrangement is as follows:—

12. Upper Graptolite Shales (= Coniston and Gala Groups of Britain).
11. Brachiopod Shales.
10. Trinucleus Shales.
9. Chasmops Limestone.
8. Middle Graptolite Schists (divisible into three zones, and represented in Britain by the Llandeilo Beds and Moffat Shales).
7. Orthoceras Limestone.
6. Lower Graptolite Shales (= the Skiddaw Slate of England).
5. Ceratopyge Limestone.
4. Dictyonema Beds.
3. Olenus Beds (= the Lingula Flags of Britain).
2. Paradoxides Beds (= the Menevian of Britain).
1. Sandstone.

In addition, the more recent Klinte Sandstone was noticed, and assigned to the Ludlow, a parallelism already arrived at by Lundgren. The new title of Dictyonema Shales was proposed by Linnarsson for the highest zone of the Alum Shales with Dictyonema, answering to part of the Tremadoc Shales of North Wales.

During the same year Linnarsson wrote the description illustrating the sheet "Latorp" of the Swedish Survey, including in the memoir the results of his discoveries to this date, and giving much valuable original matter respecting the character and arrangement of the crystalline strata and the superficial accumulations of the country.

In a paper on the Brachiopoda of the Paradoxides beds of Sweden, published during the year 1875, Linnarsson for the first time separated the Lower Cambrian or Paradoxides beds of Sweden into their natural subdivisions. The zones he recognized are given as follows:—

6. Beds with *Agnostus lævigatus.*
5. ,, *Paradoxides Forchhammeri.*
4. ,, ,, *Ölandicus.*
3. ,, ,, *Davidis.*
2. ,, ,, *Tessini.*
1. ,, ,, *Kjerulfi.*

The zone with *P. Ölandicus* was referred to the fourth place in the series with doubt, and it is only within the past few months that its true place has been found by Dr. Nathorst to lie between Zones 1 & 2.

The summer of 1875 was devoted by Linnarsson to the investigation of the Palæozoic strata of Ostrogothia; but he also made a brief tour to the islands of Gothland and Oesel.

He published a small memoir descriptive of his work in the latter island in the following year, and discussed the question of the natural arrangement of its fossiliferous rocks.

In the year 1876 also he contributed a paper to the pages of the GEOLOGICAL MAGAZINE, drawing a careful comparison between the oldest fossiliferous strata of Northern Europe and those of Britain, and contending that the oldest Scandinavian strata and fossils are at least of equal antiquity with those Cambrian fossiliferous deposits discovered by Dr. Hicks in the neighbourhood of St. Davids.

(*To be concluded in our next Number.*)

## REVIEWS.

### I.—TRAITÉ DE GÉOLOGIE. Par A. DE LAPPARENT, Professeur à l'Institut Catholique de Paris. Fasc. 1-4. (Paris, 1881: F. Savy.)

OF the manuals devoted to the study of geological science in France, few only appear to be adapted to the requirements of the advanced student, or have the detailed character of some of those published in Germany, America, and England, by Credner, Naumann, Dana, Lyell, or Jukes. Apparently the most important, certainly for the time, are the Traité de Geognosie, 1819, by D'Aubuisson de Voisins, and the Nouveaux Eléments of M. Huot in 1837. The valuable Leçons de Géologie pratique, by Elie de Beaumont, and the later works of Beudant, Gosselet, Leymerie, Vézian, Contejean, D'Halloy, Raulin, and Lambert are satisfactory and useful elementary manuals, but not quite so full of details as the works of the authors above noticed.

To supply this deficiency, and to systematize the leading facts and principles of the science according to his view of placing them before the student, has been the object of M. de Lapparent in this new treatise of geology, and which, doubtless, embodies the method of instruction given by him as Professor at the Catholic Institute of Paris during the last six years.

A practical field geologist of the school of Élie de Beaumont, and as co-editor for fifteen years with the late M. Delesse, of the Revue de Géologie (now unfortunately suspended), has made him acquainted with a wide range of geological literature and the facts and opinions of numerous authors, and thus materially assisted in the preparation of this work, not without, however, feeling the difficulties of the task, but with the hope "en l'adaptant aux nécessités de la science actuelle, l'ensignment des maîtres qui lui ont ouvert la voie."

The introduction contains a definition of the subject, an exposition of the methods and application of geology, and a short sketch of the history of the science. According to the principles explained in the introduction, the work will be divided into two sections, the first of which will be devoted to the study of present phenomena, under the heads of terrestrial morphology, physiography, and to the external and internal dynamical agencies.

The second section will treat of geology proper or the study of the phenomena of past time, such as the general composition of the earth's crust, the sedimentary strata or those of external origin, the eruptive rocks or those of internal origin, the changes and dislocations which the crust of the globe has undergone, and the various geological theories.

The first three Livraisons comprise some of the phenomena belonging to the first section, and show considerable attention to the selection and arrangement of the facts bearing on the principles of geology and the causes at present in operation.

The fourth Livraison concludes the account of the most important geysers, as those of Iceland, New Zealand, Yellowstone Park, and the Azores, treating of their chemical phenomena, and the origin of the siliceous and calcareous substances deposited by them.

The other evidences of declining volcanic activity, as Suffioni, thermal springs, gaseous exhalations of carbonic acid (moffetes) and of hydrocarbons, are succinctly treated, M. de Lapparent considering that the "ensemble" of volcanic phenomena from the most violent paroxysms to the simple *mofettes* form one continuous and admirable ordinate series.

The fourth section, which concludes the first part of the work, describes the various facts and phenomena connected with earthquakes (in which the views of Mr. Mallet and other authors are fully considered), and of the oscillations of the earth's crust, in relation to the elevation of shore-lines, and of land-surfaces, the author observing, that the great movements of the crust of the globe and the various volcanic manifestations are chiefly due to the progressive cooling of the inner igneous nucleus.

The second part, or geology proper, commences with a description of the mineral constituents of rocks, either as essential or accessory minerals, followed by an account of the chemical and mechanical processes for the examination of rocks, and of their classification, under which the author proposes three main divisions,—acid, basic, and neutral rocks; these are again divided into an ancient and a modern series, with a further subdivision based upon their texture, as the granitoid, trachytoid and vitreous types. Three tables are given, pp. 579, 591, and 606, showing the kinds of rocks belonging to each division, and an appendix on meteorites.

The work will consist of seven parts, forming a volume of about 1100 pages, with 500 illustrations, so that, when completed, in the same methodical and instructive manner as the portion already published, it will form a valuable manual of physiography and geology both for the general reader and the advanced student of the science. J. M.

II.—INTRODUCTORY TEXT-BOOK OF PHYSICAL GEOGRAPHY. By the late DAVID PAGE, LL.D., F.G.S. Tenth Edition, Revised and Enlarged by Professor C. Lapworth, F.G.S., etc. (Edinburgh and London, 1881: W. Blackwood and Sons.)

THE Text-book of Physical Geography by the late Dr. Page having reached the tenth edition is fair evidence of its being a satisfactory and useful introduction to the subject. The present edition has been prepared by Prof. Lapworth, who has carefully revised and enlarged it, so as to bring up the information it contains to the present date. Certain corrections and additions have been made throughout from information derived from the later researches and speculation bearing on physics, meteorology, and biology. The additional matter has been illustrated by some new maps, but no changes have been made in the original textual arrangement of this little treatise, which is intended to convey in a systematic manner the leading facts of the science to which it relates. J. M.

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III.—THE GEOLOGY OF THE NEIGHBOURHOOD OF STOWMARKET. By W. WHITAKER, F. J. BENNETT, and J. H. BLAKE. 8vo. pp. 26. Price 1*s*. (London, 1881.)

THE systematic labours of the Geological Survey of England furnish us, from time to time, with descriptions of little-known districts, of which the work before us is an example. It is true that, in his extended survey of the glacial deposits of the East of England, Mr. S. V. Wood has drawn attention to some of the sections in the country now described in detail; but none of these appear to be sufficiently fossiliferous, or to present other features to tempt amateurs and to awaken controversy. The greater part of the area is covered by the Chalky Boulder-clay, beneath which are found certain beds of brickearth, gravel and sand, traces of Reading Beds and Thanet Sands, and possibly also of Crag; while the Chalk underlies all. This area is contained in Quarter-sheet 50 S.W. of the Survey-map, and includes the towns of Bildeston, Lavenham, Mendlesham, Needham Market, and Stowmarket. It should, however be mentioned that a deep well at Combs penetrated the Chalk (843½ feet) to the Gault and Greensand beneath. Overlying the beds before mentioned are later deposits of brickearth, gravel, and sand (grouped as Post-Glacial), and alluvium. Perhaps the most interesting deposit is that seen in the brickyards at Woolpit, where, according to Mr. Blake, the bed, a laminated brickearth, has been worked since the time of Queen Elizabeth, and furnishes excellent white bricks. This deposit occurs directly beneath the Boulder-clay, and in point of age may, perhaps, be compared with the bed at Thetford, grouped by Mr. Skertchly with his "Brandon Beds." Mr. Whitaker, however, is inclined to regard the brickearths that underlie the Boulder-clay in this district as lenticular masses in the gravels and sands (="Middle Glacial" of Mr. Wood).

A number of well-sections give additional value to this Memoir, which is edited by Mr. Whitaker, although the greater part of the field-work was done by Mr. Blake. H. B. W.

# REPORTS AND PROCEEDINGS.

## Geological Society of London.

I.—January 11, 1882.—R. Etheridge, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Chalk masses or Boulders included in the Contorted Drift of Cromer, their Origin and Mode of Transport." By T. Mellard Reade, Esq., F.G.S.

The author referred to the occurrence in the Contorted Drift of Cromer of large masses of chalk, and came to the following conclusions:—The travelled masses are derived from sea-cliffs and the result of landslips, aided by the penetration of water forming ice, intrusive in fissures which detached them from the parent rocks. Water rising from subterranean sources accumulated as ice around the fallen masses, and was then frozen into the shore-ice. Ice-floes brought into contact with these masses were also frozen into them, forming a raft capable of floating away the boulders. The incline of the shore and the rise and fall of the tides on the breaking up of the ice would suffice to launch the rafts into the sea, and they probably floated in water not more than 200 feet deep. The frequency of these boulders and their accumulation in the Cromer deposit points to their having been arrested by the shoaling of the water and by stranding on a submarine bank. The nature of the chalk showed that they had not travelled far.

2. "Observations on the two types of Cambrian beds of the British Isles (the Caledonian and Hiberno-Cambrian), and the conditions under which they were respectively deposited." By Prof. Edward Hull, LL.D., F.R.S., F.G.S.

In this paper the author pointed out the distinctions in mineral character between the Cambrian beds of the North-west Highlands of Scotland and their assumed representatives in the east of Ireland and in North Wales. In the former case, which included the beds belonging to the "Caledonian type," the formation consists of red or purple sandstones and conglomerates; in the latter, which included the beds belonging to the "Hiberno-Cambrian type," the formation consists of hard green and purple grits and slates contrasting strongly with the former in structure and appearance.

These differences the author considered were due to deposition in distinct basins lying on either side of an Archæan ridge of crystalline rocks which ranged probably from Scandinavia through the central highlands of Scotland, and included the north and west of Ireland, with the counties of Donegal, Derry, Mayo, Sligo, and Galway—in all of which the Cambrian beds were absent,—so that the Lower Silurians repose directly and unconformably on the crystalline rocks of Laurentian age.

As additional evidence of the existence of this old ridge, the author showed that when the Lower Silurian beds were in course of formation, the Archæan floor along the west of Scotland must have sloped upwards towards the east; but he agreed with Professor Ramsay that the crystalline rocks of the Outer Hebrides formed the western limit of the Cambrian area of deposition, and that the basin was in the form of an inland lake.

On the other hand, looking at the fossil evidence both of the Irish and Welsh Cambrian beds, he was of opinion that the beds of this basin were in the main, if not altogether, of marine origin, and that the basin itself had a greatly wider range eastward and southward,—the old Archæan ridge of the British Isles forming but a small portion of the original margin.

3. "The Devonian-Silurian Formation." By Prof. E. Hull, LL.D., F.R.S., F.G.S.

The beds which the author proposed to group under the above designation are found at various parts of the British Isles, and to a slight extent on the Continent. The formation is, however, eminently British, and occurs under various local names, of which the following are the principal:—

### ENGLAND AND WALES.

*Devonshire.*—The Foreland Grits and Slates lying below the Lower Devonian beds ("Lynton Beds").

*Welsh Borders.*—"The passage-beds" of Murchison, above the Upper Ludlow Bone-bed. and including the Downton Sandstone, and rocks of the ridge of the Trichrug. These beds form the connecting link between the Estuarine Devonian beds of Hereford (generally, but erroneously, called the "Old Red Sandstone") and the Upper Silurian Series.

*South-east of England* (Sub-Cretaceous district).—The author assumed, from the borings at Ware, Turnford, and Tottenham Court Road described by Mr. Etheridge, that the Devono-Silurian beds lie concealed between Tottenham Court on the south and Hertford and Turnford on the north.

### IRELAND.

*South.*—"The Dingle Beds," or "Glengariff Grits and Slates," lying conformably on the Upper Silurian Beds, as seen in the coast of the Dingle promontory and overlain unconformably by either Old Red Sandstone or Lower Carboniferous beds, 10,000 to 20,000 feet.

*North.*—"The Fintona Beds," occupying large tracts of Londonderry, Monaghan, and Tyrone, resting unconformably on the Lower Silurian beds of Pomeroy, and overlain unconformably on the Old Red Sandstone or Lower Carboniferous beds, 5000 to 6000 feet in thickness.

### SCOTLAND.

Beds of the so-called "Lower Old Red Sandstone," with fish and crustaceans, included in Professor Geikie's "Lake Orcadie, Lake Caledonia, and Lake Cheviot," underlying unconformably the Old Red Sandstone and Lower Calciferous Sandstone, and resting unconformably on older crystalline rocks. Thickness in Caithness about 16,000 feet.

The author considered that all these beds were representative of one another in time, deposited under Lacustrine or Estuarine conditions, and, as their name indicated, forming a great group intermediate between the Silurian on the one hand and the Devonian on the other. He also submitted that their importance, as indicated by their great development in Ireland and Scotland, entitled them to a distinctive name such as that proposed.

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II.—January 25, 1882.—R. Etheridge, Esq., F.R.S., President, in the Chair.

The following communications were read:—

1. "On the Fossil Fish-remains from the Armagh Limestone in the Collection of the Earl of Enniskillen." By James W. Davis, Esq., F.G.S., F.L.S.

The author described in this paper a large collection of fossil fish-remains at present at Florence Court, Enniskillen, but which will soon be removed to the new Natural History Museum in the Cromwell Road. The collection comprises, besides specimens collected by the Earl of Enniskillen from the Carboniferous Limestone of Armagh, a large series acquired from the famous collection of the late Captain Jones, M.P., the remaining portion of which is in the Geological Museum of Cambridge. Several genera and species were described by Prof. Agassiz in his "Recherches sur les Poissons Fossiles" (1833–43), and again referred to by (General) J. E. Portlock, F.R.S., in his "Report on the Geology of Londonderry and parts of Tyrone and Fermanagh" (1843).

In 1854 Prof. M'Coy described many new genera and species in his work on the "British Palæozoic Rocks and Fossils," principally derived from a study of the portion of Capt. Jones's collection deposited in the Cambridge Museum. Prof. Agassiz paid a visit to Florence Court in 1858, and appended names to some of the fossil teeth in Lord Enniskillen's cabinets, intending to describe and figure the new forms, and to revise the whole of his former work. His death prevented this intention from being carried into effect. As far as possible the determinations of Prof. Agassiz have been adhered to in the present paper.

The detached and isolated condition in which the remains are found renders any appreciation of the relationship of the teeth and spines, or even of the teeth only, to each other extremely uncertain and difficult. Some speculations as to the probable organization and characteristics of the Carboniferous fishes which they represent, evolved during a long consideration of the specimens, have therefore been postponed to a future opportunity.

The following is a list of the genera and species described in the paper:—

*Ctenacanthus plicatilis, C. dubius, C. lævis, C. pustulatus, C. tuberculatus, Compsacanthus carinatus, Cosmacanthus marginatus, C. carinatus, Lispacanthus retrogradus, Cladacanthus paradoxus, C. major, Gnathacanthus triangularis, Cladodus polyodon, C. curvus, C. destructor, Carcharopsis Colei, Copodus cornutus, C. furcatus, C. spatulatus, C. minimus, Labodus prototypus, L. planus, Mesogomphus lingua, Pleuragomphus auriculatus, Rhymodus transversus, R. oblongus, Cha-*

*racodus angulatus, C. luneatus, Pinacodus gonoplax, P. gelasi, Dimyleus Woodi, Mylax batoides, Mylacodus quadratus, M. Sesarma, Homalodus trapeziformis, H. quadratus, Petalodus quadratus, P. recurvus, P. inequilateralis, Polyrhizodus magnus, P. Colei, P. elongatus, P. sinuosus, P. attenuatus, P. constrictus, Chomatodus linearis, C. acutus, Glossodus marginatus, Harpacodus dentatus, H. clavatus, Streblodus oblongus, S. Colei, S. Egertoni, Deltodus sublævis, D. expansus, D. nobilis, Deltoptychius acutus, D. gibberulus, Sandalodus Morrisii, Psephodus magnus, Pœcilodus Jonesii, P. gibbosus, Tomodus convexus, Xystrodus striatus, X. angustus, X. Egertoni, Helodus crassus, H. tenuis, H. clavatus, H. dilatatus, H. acutus, H. Richmondensis, H. triangularis, H. biconus, H. expansus, Rhamphodus dispar, Petalorhynchus psittacinus, Pristodus falcatus.*

2. "On an extinct Chelonian Reptile (*Notochelys costata*, Owen) from Australia." By Prof. Owen, C.B., F.R.S., F.G.S.

The fossil reptilian remains hitherto transmitted to the author from Australia have been limited to parts of the skeleton of *Megalania prisca*, Owen. The present specimen, sent last year by Professor Liversidge, is the first fossil Chelonian. The specimen was found in a formation at Blinder's River, Queensland, of which the nature and age are not stated. It is, however, petrified. The fossil consists of the anterior portion of the carapace and of the plastron, brought into unnaturally close contact by posthumous pressure. A minute description of the several parts was given, from which the author concluded that though the characters of the carapace might be interpreted as identifying the Chelonian with a true turtle (*Chelone*), those of the plastron show the well-marked distinctions of *Trionyx* and *Chelys*. On the whole, however, the modifications, especially of the carapace, show a nearer affinity to the marine turtles (*Chelone*) than the known Chelydrians exhibit, and indicate a more generalized type.

3. "On the Upper Beds of the Fifeshire Coal-Measures." By the late E. W. Binney, Esq., F.R.S., F.G.S., and James W. Kirkby, Esq.

These beds are best exposed in Fife, between the mouth of the Leven and East Wemyss. The Coal-field of the latter district is the most northerly piece of true Coal-measures in Britain; they dip 10° E., or even less. The highest member (which may possibly be even later than the Carboniferous Period) is an unfossiliferous purplish sandstone, full 200 feet thick; next comes soft red marl, 12 feet, followed by sands, 290 feet, marls, clays, etc., 100 feet, and sandstones, clays, etc., with thin coal and limestones, about 80 feet. Other sections were also described. No unconformity has been noticed in Fifeshire between these and the underlying measures. The argillaceous limestones and their coals are fossiliferous; there are a few fish and crustacea, and many plants, with some curious markings, which may be rootlets or perhaps algæ. The last occur only in a limited part of the rock, not with other plants, and are very delicate and membranous. The affinities of these were fully discussed, the author inclining to the view that they are algæ.

III.—**February 8, 1882.**—R. Etheridge, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "Description of some Iguanodon Remains discovered at Brook, Isle of Wight, indicating a New Species, *Iguanodon Seelyi.*" By J. W. Hulke, Esq., F.R.S.

After referring to the *Iguanodon* remains preserved in the Brussels Natural History Museum, the author described some fossils obtained by him in 1870 from a bed between the red and purple clays and the flint gravel capping the cliff in Brook Bay. The ilium, when complete, was not less than 124 centim. long, with a maximum vertical extent of 33 centim. The dorsal border is stout and slightly overhangs the outer surface. The præacetabular process is relatively short, and the postacetabular part of the bone tapers more than in Mantell's *Iguanodon.* The femur, when entire, could not have been less than 108 centim. long; the girth of the condyles is 82 centim., and their breadth 32 centim.; the tibia is shorter than the femur. Both metatarsi demonstrate the existence of but three functional toes; the middle metatarsal is the longest, attaining 35·5 centim., the outer metatarsal 29 centim., and the inner 26 centim.; the inner toe has three phalanges, the middle four, and the outer toe five. The toes of the *Iguanodon* therefore correspond to the second, third, and fourth toes of *Hypsilophodon.* The ungual phalanx of the inner toe is 17 centim. long, that of the middle toe nearly 18 centim. long, and that of the outer toe about 15·5 centim. long.

The humerus is about 10 centim. long. Its proximal end has a well-developed posterior or inner process, and a large deltoid crest. The caudal vertebræ, three probably between the 4th and the 10th in this series, have very four-sided articular surfaces suggestively like those hitherto referred to *Pelorosaurus.* The chevron bones are very stout and long. The differences in their ilia show this and Mantell's *Iguanodon* to be specifically distinct; and with this new *Iguanodon* the author connected the name of C. Seely, Esq., M.P., of Brook House, in recognition of his courteous permission to excavate the cliff for the recovery of the fossils, naming it *Iguanodon Seelyi.*

1. "On a peculiar Bed of Angular Drift on the high Lower-Chalk Plain between Didcot and Chilton." By Prof. J. Prestwich, M.A., F.R.S., F.G.S.

In making a railway from the main line to Chilton, this bed of drift was cut through for a depth of about 1¼ mile. It lies on a flat plain extending from the foot of the escarpment of Upper Chalk to the top of that of Lower Chalk. In places it is full 28 feet thick. At first a fine chalk rubble, it becomes after a while coarse, and is divided by clay-beds into an upper and a lower deposit. Here small boulders and bones occur, the latter much shattered; but *Elephas primigenius, Rhinoceros tichorhinus* (?), *Bison priscus, Cervus tarandus, Equus,* etc., have been identified. The boulders are Sarsen-stone, and there are small fragments of flint. Shells of *Pupa marginata, Helix hispida,* and *H. pulchella* have been found. The drift (which is widely spread) is from 150 to 260 feet above the

Thames, at highest 407 feet above the sea. The author compares it with the rubble-beds overlying the raised beaches of Sangatte and Brighton. It is unconnected with any river-course, is not of marine origin, and its materials, where not local, are derived from the southward.

## CORRESPONDENCE.

### DR. CALLAWAY *versus* MR. G. H. KINAHAN.

Sir,—Mr. Kinahan, in his observations in your current issue on my paper, "On the Rocks South of Wexford," which appeared in your November Number, is, I think, a little too sweeping in his assertions. It is incorrect to say that I pronounced his work wrong without first seeing it. I examined carefully all the localities he was kind enough to point out, and others which seemed likely to throw light upon my special investigation, except the Saltee Islands, which, from their isolation, could have no bearing on the question, and the Crossfarnoge section, which I had not time to visit. It was the less necessary to study the latter, since Mr. Du Noyer's Map favoured my views, and Mr. Kinahan's own descriptions appeared to me to admit of a similar interpretation. I believe the difference between us may be fairly stated thus: Mr. Kinahan argues that there is a passage between the metamorphic rocks and the series which he calls Cambrian (my Pebidian), because these are interstratified with the granitoid and gneissic bands of the former beds of schist similar to the adjoining beds of the latter. I hold that there in no passage, not only because there is a distinct break, but also because the schists associated with the gneiss differ widely from the so-called Cambrians, in mineral characters and degree of alteration; the schists being truly metamorphic (crystalline and foliated), while the "Cambrians" are merely felspathic shales, slates, and grits, which, having undergone some alteration, often bear a superficial resemblance to the true schists. If this statement of the case is correct, the issue between us is largely one of lithology, and the value of our observations will depend upon our respective competence to distinguish between different kinds of rocks. I cannot but think that the loose views which have prevailed, as to what constitutes a true passage between formations, have seriously vitiated much of our current geology.

I am rather surprised that Mr. Kinahan should recommend me to visit Yar-Connaught with a view of ascertaining whether there is a passage between metamorphic and unaltered Cambrian in the area south of Wexford; especially since in the former district, according to Mr. Kinahan himself (Geology of Ireland, p. 190), the metamorphic rocks graduate, not into Cambrian, but into "Cambro-Silurian."

I owe Mr. Kinahan an apology for attributing to him a change of front in describing as "Cambrian" rocks which he had, as I thought, previously regarded as "Cambro-Silurian." As he is the author of the Survey Memoir on the district in question, I naturally inferred that he was also responsible for the Map. He informs me, however, that the Map issued to me by the agents of the Irish Survey is an obsolete edition with which he had nothing to do. I am happy to vindicate Mr. Kinahan's consistency, but I cannot think that geologists will be greatly benefited by being supplied with Maps which a prominent member of the Survey declares to be superseded.

WELLINGTON, SALOP, *Dec.* 22, 1881. C. CALLAWAY.

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## LAURENTIAN ROCKS IN DONEGAL.

SIR,—It is with great reluctance that I feel obliged to reply to the letter of Mr. Kinahan which appears in the current Number of the GEOLOGICAL MAGAZINE, as it might be supposed by some who may have read this letter that I have been endeavouring to take from my late friend and preceptor, Professor Jukes, the credit of having first made the discovery of Laurentian rocks in Donegal, and in other parts of Ireland—a charge which I unequivocally deny.

On seeing Mr. Kinahan's letter in the December Number of the GEOL. MAG. in which he states (p. 575), "While in reality the question" (of the existence of Laurentian rocks in Donegal) "has not been worked out since Jukes first suggested they were Laurentian rocks," I wrote to Mr. Kinahan to ask for his authority for this statement, inasmuch as I had, when reading over papers on the Geology of Donegal, been unable to find anything to support it. The following is a copy of my letter and of Mr. Kinahan's reply:—

"DUBLIN, 6 *Dec.* 1881.

"SIR,—In the current number of the GEOLOGICAL MAGAZINE there appears a letter in which you state that 'In Donegal we are now told that undoubtedly there are Laurentian rocks, while in reality the question there has not been worked out since Jukes first suggested they were Laurentian rocks.' As I have been unable to discover any suggestion to the above effect in the writings of Professor Jukes, I would be obliged to you to inform me on what authority you have made the above statement.—I am, Sir, your obedient servant,

"To G. H. Kinahan, Esq. EDWARD HULL."

The following is Mr. Kinahan's reply (by post-card):—

"Letters like that about the Geol. Mag. have no official bearing. I may however tell you to read the first chapter of the Geol. of Ireland written and in print in my book before the Laurentian craze set in.

"7. xii. 81. G. H. KINAHAN."

On referring to the passage in Mr. Kinahan's book, all I can find bearing on the subject is as follows:—"Rocks older than the Cambrian formation are not known in Ireland; but Jukes suggested that some of the highly metamorphosed rocks of the North of Ireland might possibly be Pre-Cambrian."

It would appear, therefore, that in making the statement contained in the GEOL. MAG. for December, Mr. Kinahan quotes from himself, but there is no reference to any published expression of Mr. Jukes' views here or elsewhere.

It would appear, however, from Mr. Kinahan's second letter, that the whole statement rests on his recollection of conversations on the "probability" of Laurentian rocks existing in Donegal and elsewhere in Ireland. But if so, Mr. Kinahan must excuse me if I decline to accept colloquial speculations as scientific demonstrations. *Litera scripta manent.* Conversations are evanescent. As a matter of fact, although Professor Jukes visited Donegal in company with the Rev. Dr. Haughton, and Mr. R. H. Scott, he never hazarded *an opinion in print* (as far as I am able to discover), and by such evidence alone am I to be guided, that any portion of the Donegal rocks are of Laurentian age. When recently I read my paper *in extenso* before the Natural History Section of the Royal Dublin Society, at which both Dr. Haughton and Mr. Kinahan were present, the former disclaimed, on his own part at least, any priority in the determination of the Laurentian age of the gneissose series of Donegal.

As I stated in my original communication, which appeared in *Nature* (26th May, 1881), Dr. Sterry Hunt was the first who, from an examination of specimens from Donegal, recorded an opinion of the Laurentian age of the older series of metamorphosed beds.

Now, Sir, as regards the credit of this discovery, I beg to say that I claim no particular credit either for myself or for any one else. As the Director of the Irish Branch of the Geological Survey, I feel a certain gratification that the determination of the age of the old gneiss of Donegal, and its associated schistose rocks, has been made by officers of the Survey; for in my preliminary survey of that district I was assisted by two senior officers of the Survey, Mr. R. G. Symes. F.G.S., and Mr. F. G. Wilkinson. They can testify as to the care with which we examined an extensive district—and as to the satisfactory nature of the determination of the unconformity between the older and newer groups of metamorphosed beds. The details themselves will appear in my paper now in course of publication. The determination was made not by voluntary effort, but in accordance with official duty, and as the outcome of a previous visit to the Northern Highlands of Scotland, under the guidance of Professor Geikie, in the spring of 1880. I have not the least doubt that if Professor Jukes had had the same opportunities of observation as myself, he would have arrived at the same conclusions with regard to the age of the older series, as Harkness did with regard to the age of the newer; but, as a matter of fact, the determination of the question had not been made till the spring of last year.

I have now only to add that nothing can be more distasteful to myself than to have my name brought as it were into competition with that of my late friend and predecessor. Public duty has obliged me to deal with questions which he ably handled, and sometimes I have arrived at different conclusions regarding them. But I defy any one to point out any occasion in which I have failed to quote his published opinions when required, or to have knowingly misrepresented them. It is, therefore, quite unnecessary for Mr. Kinahan to assume the *rôle* of apologist or expositor of his former chief; and I venture to think that he is not the person whom Professor Jukes would have selected to undertake this office, had it been required.

As I do not intend to reply to any further statement on this subject, I hope the correspondence may now be considered as closed.

Geological Survey Office,
Dublin, 9 *January*, 1882.
Edward Hull.

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## THE GLACIATION OF THE SHETLAND ISLANDS.

Sir,—With your permission, I should like to say a few words regarding the discussion which has been carried on during the last year in various numbers of the Geol. Mag., as I visited part of Shetland in the summer of 1880, and although I went there chiefly for mineralogical purposes, I also noted some of the glacial phenomena.

The unequal distribution of the Boulder-clay on the sides of Dales Voe is a striking fact, for while the northern slope is covered with a considerable thickness of clay and has a smooth grassy surface halfway up the ridge, the southern slope is bare, and presents mammillated hummocks of rock. Northwards from this point the whole tract of country has a peculiar ice-worn aspect; but on account of the rocks being mostly of a schistose nature, they do not afford so striking evidence as to the direction of the ice-flow. However, I noted a few striæ pointing nearly N.E. and S.W.

Near Busta Voe a tract of diorite occurs, and on this tract numerous erratics occur, similar, so far as I could determine, to the micaceous and gneissose rocks which lie to the north-east. Further north, in the neighbourhood of Isleburgh and Sulem Voe, the rocks have been very much worn, and in many places show bare hillocks of rock moulded off into flowing outlines and covered with scratches. Near Pondswater Loch the striæ on an average point W. to W. 10 S., and in the same locality boulders of gneiss, schist, and granite are common. Further north, but still on the diorite area, there are numerous boulders of gneiss and schist, but I was unable to discover any of granite. If we assume that the ice-sheet came from the eastward, the fact is accounted for, because there would be no granite in the track of the ice. On the small patch of metamorphic schists at Hillswick I saw several boulders of diorite, and as there is no diorite known to exist on the west side of Hillswick Bay, there is every probability that these boulders were carried across the Bay, but the most conclusive proof that such has been the case is afforded by a fine section of Boulder-clay lying in a hollow to the west of Hillswick. The lower part of this is entirely composed of the *débris* of the schists on which the clay rests, while the upper part is largely composed of blocks of diorite and a few of the other rocks which lay in the path of the ice-sheet.

The areas south of Ronas Voe and west of Hillswick show that blocks of schist have invaded the felsitic area, while blocks of these have in their turn invaded the porphyrite area. I looked for porphyrites to the east of the fault which cuts them off from the felsitic granite, but found none.

Mr. Milne Home seems to have misapprehended a great deal of Messrs. Peach and Horne's evidence regarding the dispersal of the stones in the Boulder-clay in the northern part of the mainland, for while he asserts that their conclusions are wrong, he ignores the evidence they produce, such as the invasion of one area by boulders from another, and the gradual decrease in the number of the boulders as they recede from their parent source.

I had not sufficient time to search for numerous instances of striæ; but so far as the disposal of the stones are concerned, I can corroborate Messrs. Peach and Horne's observations in the greater part of Northmavine; and see no escape from the conclusion that, to the north-west of Hillswick, the ice-sheet flowed from the S.E. to N.W., while further south, and on the east side of the island, the direction was from north-east to south-west. THOMAS STEWART.

WATER WORKS, GLASGOW, 14th *Dec.* 1881.

## MR. HOWORTH'S REPLY TO MR. REID.

SIR,—In his former note Mr. Reid spoke of the theory of violent changes as extinct. To this I replied that in calling it extinct he must have overlooked the weighty opinion of Continental geologists. Mr. Reid now confesses that he did so, and that he was merely speaking of geologists on this side of the Channel, and he proceeds to justify his limitation by a sweeping depreciation of recent Continental writers on Post-Glacial geology. It certainly seems extraordinary that such an experienced and deservedly widely-known observer as Mr. Reid should permit himself to write thus in your widely-circulated pages. I hope I have as great a respect for the magnificent work done by Mr. Prestwich and those who have succeeded him as any one; but I must confess, and others will assuredly echo my words, that, judged by the abundance of its facts, the careful sifting of its evidence, and the brilliant character of its induction, no work produced on this side of the Channel, in recent years, dealing with Post-Glacial geology, can compare with M. Belgrand's *magnum opus* on the Seine Valley; while it is literally incredible how any one who has read any considerable number of the memoirs which have seen the light in recent years in France, Belgium and Italy, dealing with this very difficult period, can speak of them as in any way inferior to the contemporary writings of English geologists. They far exceed in number and in minuteness of treatment similar memoirs written here, for the very good reason that the people whose interest in these deposits has been excited by the discovery of remains of Palæolithic man in them is very much in excess there of what it is here. Leaving, however, this debateable land, where rival national reputations are necessarily weighed in a very uncertain balance, what is to be said of what follows? Mr. Reid tells us that "In most parts of the Continent the Pleistocene deposits appear to be represented by one tolerably uniform mass, like the Loess of the Rhine, or the Tundras of Siberia." Is this so? I was under the impression that the number and variety of the so-called Pleistocene beds in France and Southern Russia should be described by any adjective rather than *uniform*. Having postulated this, Mr. Reid contrasts the deposits on the Continent with the wonderful variety of the beds in Britain, their fossiliferous character, and the splendid series of cliff sections and caves here. What can be the meaning of this? Where have we such continuous sections through these same deposits as can be shown in the banks of the great rivers of the Continent? In what respect are these deposits richer in fossils here than there? How are the British caves better situated for deciding the question than the caves of Belgium? I cannot understand what Mr. Reid means. We may indeed institute a comparison, but it is very different to the one made by him. When we cross the Channel, we find the Post-Glacial beds arranged in continuous series over an area of 200 degrees of longitude, in many places *in situ*, and undisturbed in sections showing the whole of the beds; while in Britain we are on the extreme edge of these formations, where they are dislocated and broken and fragmentary. Assuredly it follows that on the Continent we have every element for studying the problem correctly, while here we are in perpetual danger at every turn of mistaking a local and sophisticated section for one that is normal.

Mr. Reid contrasts my humble position as an antiquary given to respecting authority with his own exalted one of a Member of the Geological Survey, "who has learnt to believe nothing that he is told and only one-half of what he sees." I am not sure that this is a desirable byeway into which to drag the controversy. Such contrasts might if pressed lead to some unexpected comments. Surely it is better to put aside both geologist and antiquary for the nonce, and to address each of your readers as if he were a keen Philistine apt at judging evidence. Not merely *evidence of the senses*—for the facts are not in issue; we are agreed about the facts; but the more important evidence of *inference* and *induction*. In this view may I point your readers to another sentence of Mr. Reid's? He says: "The extermination of the Mammoth in Britain and Germany may be referable to human agency, while in Siberia it was gradually killed by the cold and want of food."

May I ask, nay, entreat, Mr. Reid to furnish one tittle of evidence in support of this emphatic statement? I have tried to supply your readers with a very considerable amount of evidence, all of which tells entirely against such a view. Mr. Reid cannot seriously suppose that all this evidence can be answered by an *obiter dictum*, a mere dogmatic assertion without any proof whatever, and that your readers will accept it as conclusive, even if all that most exalted brotherhood to whom this generation is under such deep obligations, viz. the Geological Surveyors, were to shout the aphorism in chorus. As to the statement that the Mammoth together with his companions were exterminated *by man* in Europe, I fear that the Philistine crowd, when it confronts such a statement with our present knowledge, will assuredly smile diplomatically, if it does not have recourse to some unseemly sarcasms.

Mr. Reid says a decrease of one degree in the temperature in a century would be very rapid from a geological point of view.[1] I reply, whether rapid or the contrary, the problem I have invited

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[1] Would it not be safer to say from Mr. Reid's geological point of view?

Mr. Reid, and those who think with him, to solve, and which I cannot find any one willing to face, is how, with such a change only as one degree in a century, or anything like it, we are to account for the preservation of the flesh of the Mammoth in a series of carcases found in the whole length of Siberia, and the condition of which will not admit of their having been thawed once since they were first frozen. There is the gauge. I challenge Mr. Reid to pick it up, and to give us something in the shape of a reasonable explanation.

Mr. Reid disapproves of my quoting Cuvier and Buckland and D'Archiac, inasmuch as they are obsolete authorities on this point. Why D'Archiac—whose career was parallel with Lyell's, whose opinions are quoted by Lyell with the greatest respect, and whose text-books are those in ordinary use in France—should be deemed in any way an obsolete authority, considering the immense amount of work he did in elucidating these very deposits, I know not. As to the other two names, I only quoted them as a protest against Mr. Reid speaking superciliously of a theory which had the imprimatur of such excellent observers. Perhaps before the subject is thrashed out, we shall be able to furnish him with a list of names which will surprise him, of geologists who have virtually indorsed Cuvier's and Buckland's views on the subject, and this too quite recently.

Mr. Reid says: "After several years of study of Pleistocene beds, I think that as a rule things did then progress faster, and that we are now in a position of exceptionally slow changes." This I most cordially accept, but I must say that this is not the Uniformitarian doctrine laid down by the leader of the Uniformitarian school in England, a most distinguished geologist very well known to Mr. Reid, on a famous occasion not three years ago. I also accept Mr. Reid's restriction of the invocation of cataclysm to cases which cannot be explained without it. It is because I have been for years trying to find *an adequate* explanation of this very difficulty, without invoking a cataclysm, and have failed, that I have written the papers which have appeared in the GEOLOGICAL MAGAZINE. I most cordially invite Mr. Reid or anybody else to try to solve the matter. Not however by *ex cathedra* statements. The problem is much too difficult and the evidence much too consistent on one side to admit of its being dismissed by one of those superficial waves of the hand which neither antiquaries nor Philistines have been trained to appreciate. The world cannot in these days be addressed, at least in the domain of science, in this pontifical fashion, and is apt to resent it. At all events that unmannerly part of the world which lives in Lancashire requires some definite reasons before it does the kowtow, and submits to oracular dicta. We are not discussing matters of fact which have come under the observation of such good eyes as those of Mr. Reid, and which we should at once accept, but *inferences* from facts of which we claim to be as good judges and as well trained as the great men whose Olympus is in Jermyn Street. I hope Mr. Reid will forgive my treatment of his reference to the antiquaries. If I did not value very highly his opinion, and his work, I should not be scribbling this letter.

*DERBY HOUSE, ECCLES, Jan. 10th*, 1882. HENRY H. HOWORTH.

## SUBSIDENCES AT BLACKHEATH.

SIR,—I shall be glad if you can afford space for a few remarks on the letter of the Rev. Osmond Fisher in the current Number of the GEOLOGICAL MAGAZINE.

Mr. Fisher asks, in the first place, if these subsidences are a new feature at Blackheath. In reply I have to state that, in addition to the three subsidences mentioned in the Report of the Subsidence Committee, three others (at least) are known to have occurred within the memory of persons now living, though I am unable to give precise dates. But as two of the three were just outside the limits of the open space at Blackheath, and the third, though on the heath, appeared in the corner of a large and irregularly-worked gravel-pit, about forty-five years ago, none of them excited much attention. The three later subsidences, on the other hand, having all been on the surface of what is practically a great open playground both for children and adults, their appearance caused general alarm. Again, in Charlton Park, little more than a mile E. of Blackheath, and exactly like it in geology and physical geography, subsidences have appeared from time to time. But as Charlton is a private park, they remained quite unknown till Mr. F. C. J. Spurrell read his paper on "Danes' Holes" at the Archæological Institute last April. It is thus evident that only those subsidences that from their public importance have excited public interest have become generally known.

I do not think the Blackheath pits have any affinity to the Dorset pits mentioned by Mr. Fisher; the latter seem to me—judging from his letter—rather to resemble those at Whitlingham, near Norwich. At Blackheath there is nothing in the appearance of the surface to suggest the operation of any general natural cause. A large portion of its surface is smooth and flat. The rougher ground is occupied either by large disused gravel-pits or by patches of small, shallow, irregular hollows, due apparently to primitive diggings for gravel. Hasted, in his History of Kent, vol. i. (1778), speaks of the high reputation of the Blackheath gravel, which caused it to be sent to great distances. He also remarks that when the rebels under Lord Audley were defeated on Blackheath in 1497, 2000 bodies were buried there, and that their graves are now visible. Pre-existing gravel-pits were doubtless used as graves, and the slow dissolution of the corpses beneath a thin gravel covering might give rise to such hollows.

Mr. Fisher's paper on the Lexden Pit was pointed out to me a year ago by Mr. F. Rutley, who has given an alternative explanation in the same Vol. (1865) of this MAGAZINE. (By a strange oversight I only noticed a day or two ago the note referring to the paper on the Dorset pits.) But after carefully reading both explanations of the Lexden pit, the result was—to my mind—to show the difficulties in the way of any purely geological explanation; while, at the same time, no other view seems to have suggested itself either to Mr. Fisher or to Mr. Rutley, who yet differ fundamentally from each other. It was impossible, therefore, for me to have any opinion on the Lexden pit and its bearing—if any—on those at Blackheath.

It may be well to conclude by summing up briefly the grounds for coming to an archæological conclusion at Blackheath.

They are:—1st. The great improbability of any cavity in the chalk under Blackheath in consequence of the very small quantity of chalk there above the permanent water-level. This point was especially dwelt upon by Prof. Prestwich in his letter to Mr. J. K. Laughton, Chairman of the Blackheath Subsidence Committee.

2ndly. The additional improbability of any cavity in consequence of the presence of the clayey beds (10 or 12 ft.) of the Woolwich Series below the Blackheath pebble beds which form the surface.

Lastly. We were more fortunate at Blackheath than Messrs. Fisher and Rutley at Lexden, not only in having much more geological evidence, but also an amount of archæological evidence, in the pits popularly known as "Danes' Holes," which would suffice to turn the scale against a geological explanation, even were the facts against one much less weighty than they are.

28, Crooms Hill, Greenwich,
*Jan.* 10*th*, 1882.

T. V. Holmes.

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## ON THE STRATA OF COLWELL BAY, HEADON HILL, AND HORDWELL CLIFF.

Sir,—I have lately read Prof. Blake's article on the strata of Colwell Bay and Headon Hill, published in the Proceedings of the Geologists' Association for October, 1881. Since I took a somewhat (I fear) over-prominent part in the discussion of Messrs. Keeping and Tawney's paper to which it refers, I should wish to say a few words on the subject.

I cannot think it can be fairly asserted that Prof. Judd's views "were attacked by Messrs. Tawney and Keeping in a spirit unjustifiable in any scientific controversy." When we recollect that one of the authors was born in the Isle of Wight, and spent the best years of his life in professional work, chiefly in exploring and collecting from the Eocene beds of the district, some little amount of warmth was justifiable in defending, what were his own well-matured views, as well as those of the Surveyors, against an attack, which, however learned, was apparently based upon work in the library and museum.

Palæontological evidence is a powerful assistant to stratigraphy, but it must yield precedence to results clearly made out in the field. My own investigation of the section certainly supports the views of the Surveyors, as reasserted by Messrs. Keeping and Tawney. Indeed, Mr. Blake appears to me to feel a difficulty in avoiding the same conclusion. But it is remarkable that he does not seem to have applied my crucial test, referred to in Messrs. Keeping and Tawney's paper, of searching for (and finding) the "Venus" bed in the Totland's brick-field, at the part where, though continuous inland, it has been denuded off the cliff, between Widdick and Weston Chines.

It is my own opinion that the relations of this somewhat complicated series, in the Isle of Wight, would be made clearer to students, who would compare it with the corresponding series on the coast of the mainland. I therefore send you, copied from a rough note-book, an ascending section made by myself in April, 1853. I do not vouch for the correctness of the genera named. The date of the observations must be taken as an excuse for *errors*.

### ASCENDING SECTION AT HORDWELL CLIFF, GOING FROM BEACON BUNNEY EASTWARD.

| | BARTON CLAY. | ft. | in. |
|---|---|---|---|
| 1. | Sandy blue clay, *Ancillaria*, *Oliva*, *Perna*, etc. | | |
| 2. | White sand passing into greenish clay with lenticular masses of shales. (Searles Wood gives the following list:[1] *Oliva*, *Potamides*, *Ancillaria*, *Natica*, *Sanguinolaria* (? *Psammobia*), *Venericardia*, *Cytherea*, *Lucina*, *Potâmomya*) | 18 | 0 |
| 3. | Lignite | 0 | 4 |
| 4. | Green sandy clay with *fuci* | 0 | 8 |
| 5. | Blue laminated clay abounding in *Corbula*, *Cyrena*, *Mytilus* (? *Dreissena*), and *Cerithium* | 0 | 6 |
| 6. | Carboniferous clay | 1 | 10 |
| | FRESH-WATER. | | |
| 7. | Greenish and bluish sands and clays with *Paludina* | 8 | 0 |
| 8. | Nodular marly rock | 1 | 0 |
| 9. | Greenish clay (say) | 10 | 0. |
| 10. | Brown sand with stems of *fuci* | 3 | 6 |
| 11. | White sand passing into clay | 4 | 0 |
| 12. | Grey sand | 1 | 0 |
| 13. | Band of *Potamomya* | 0 | 6 |
| 14. | White sand (*Crocodile bed*) | 8 | 0 |
| 15. | Ferruginous marly nodules | 1 | 0 |
| 16. | Grey clay | 4 | 0 |
| 17. | *Limnea* marlstone | 0 | 6 |
| 18. | Greenish clay (? *Dreissena*) | 2 | 6 |
| 19. | Band with small *Mytilus* and *Physa* | 0 | 4 |
| 20. | Greenish-white clay | 7 | 0 |
| 21. | Yellow sand, small spiral shells, *Gyrogonites* and *black seeds* | 1 | 0 |
| 22. | Carbonaceous clay | 1 | 0 |
| 23. | Grey sand | 1 | 6 |
| 24. | Greenish clay, blue in places, *Paludina*, *Unio* | 2 | 0 |
| 25. | Grey sandy clays abounding in vegetable stains | 2 | 6 |
| | MARINE. | | |
| 26. | Sandy foxy clay (seen)<br>(This corresponds to the "Venus bed,' or Middle Headon.) | 5 | 0 |

It will be seen from the above section that the calcareous bands (17, etc.) of Hordwell, belonging as they do to the first fresh-water series above the Barton, must be correlated with the Lower Headon Limestones, of which the How Ledge Limestone is the top. They do not represent the Great Upper Headon Limestone. Any correlation of the beds of Hordwell Cliff with those of Colwell Bay will therefore be misleading; the former being below the horizon of the How Ledge Limestone, and the latter above it. The stratum on the mainland which does correspond with the Colwell Bay or Headon Hill "Venus bed," must be sought for at Hordwell above the fresh-water series; and it occurs at a place called Rook Cliff, about a mile to the east of Beacon Bunney, in a low cliff. It is usually buried under a talus of gravel. I have never seen it exposed; but I once collected a considerable number of specimens from the spot, after Mr. Keeping had been digging there, and his spoil heaps had been washed by the rain. The specimens have usually a peculiar pinkish hue, by which they may be identified in a collection.

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[1] Charlesworth's Geol. Journ. part 1, p. 4, 1846.

O. Fisher.

## DR. STERRY HUNT.

Sir,—We have just said good-bye to a distinguished American geologist, whose visit to Europe deserves a passing notice in these pages. Dr. Sterry Hunt has been long well known among us by his numerous papers on Geology, Chemistry, and Physics. There is a freshness and vigour about him that makes him welcome at any scientific gathering, and a clearness of exposition and openness of communication that forces even those who do not agree with all his conclusions to admit that at any rate his work tends always to clear away error and suggest new directions and methods of search after truth.

Thomas Sterry Hunt was born in Norwich, Connecticut, New England, in 1826, and educated at Yale College, New Haven, where, under the late Professor Silliman, he devoted himself to Chemistry, Mineralogy, and Geology. In 1847 he became a member of the Geological Survey of Canada, on which he remained until he was called to Boston as Professor of Geology in 1872. This post he held till 1878, when he resigned his official duties, and returned to Montreal to devote himself more completely to professional and scientific work. During his former residence in Canada Dr. Hunt had successively occupied professorial chairs in the Laval University, Quebec, and that of McGill, at Montreal, and from these Universities had received the degrees of Doctor of Sciences and Doctor of Laws. He is also Master of Arts of Harvard University, Member of the National Academy of Sciences of the United States, and of the American Philosophical Society, and has been for more than twenty years a F.R.S. He is an officer of the French Legion of Honour, and has received many recognitions of his services from foreign Academies and Societies.

Dr. Hunt's work during twenty-five years has been in great part devoted to the Geology and Economic Mineralogy of Canada. During this period his published investigations into more purely scientific questions also have been numerous and important, at first in the direction of organic and theoretical chemistry, and later in mineralogy. lithology, and chemical geology; his aim being from the study of the chemistry of waters, sediments, and crystalline rocks, to construct a rational theory of the processes which have presided over the early growth and development of the earth's crust, a study which he designates *mineral physiology*. In this connexion he has made important contributions to cosmic chemistry and physics. We owe to him also in great part the advance which has been made in the grouping and classification on lithological and stratigraphical grounds of the crystalline bedded rocks which present in their succession a history not less varied and extended than that of the entire Palæozoic era—and which he believes are in all cases of Pre-Cambrian date.

Dr. Hunt was the principal organizer and first Secretary of the International Committee for a Geological Congress; the first meeting of which was held at Paris in 1878, and the second at Bologna in 1881, at both of which he took an active part as one of the Vice-Presidents, and by his cordiality and good fellowship, backed by ability and knowledge, contributed much to the maintenance of a good understanding among the representatives of all the English-speaking nations gathered at Bologna. His work did not end at Bologna, and on his way home he, first at Paris (Compte-rendu sommaire Soc. Géol. France, Nov. 7, 1881), and afterwards in London (Abst. Proc. Geol. Soc. Nov. 16, 1881), gave an account of his recent examination of the metamorphic rocks of Italy and Germany, and his views as to their correlation with the older crystalline rocks of America and Britain. He also brought before the Philosophical Society of Cambridge his matured views with regard to the distribution of extremely attenuated matter through interstellar space (Proc. Camb. Phil. Soc. Nov. 28, 1881), pointing out that practically the same idea had been suggested by Newton in his earlier work, and had taken more definite shape in later editions. The University of Cambridge conferred on him the Honorary Degree of LL.D., and we hope that this new tie may unite our spirited scientific ally more closely to us, and insure a not too long deferred return to our shore.—CANTAB.

## THE TORRIDON SANDSTONE.

SIR,—I shall be obliged if you will allow me to correct an important misprint which occurs in the abstract of the debate on my paper on the Torridon Sandstone at the Geological Society, Dec. 21st. In my reply, I am represented as saying that north-east of Queenaig the sandstone passes "*un*conformably" under the quartzite. This contradicts my main conclusion. For "unconformably" read "conformably."

WELLINGTON, SALOP, *Dec.* 31, 1881. C. CALLAWAY.

## RATE OF DENUDATION OF THE LAND BY RIVERS.

SIR,—Mr. Tylor seems to have made a slip in his calculations. $3^5$ is not 729 but 243. This makes Mr. Tylor's results three times too much. The 3000 years, of Mr. Tylor's sixth paragraph, will thus become 9000; the mean denudation not nine but three inches a year; and the annual rise of the sea-level one inch only.

In paragraph five—"the supposed period of 729 years" is probably a printer's error.

I am unable to follow Mr. Tylor's reasoning, and shall be glad of some information on the subject. For instance:

1. Where can I find Mr. Tylor's "formula of the increase of velocity of water at the same slope"?
2. Where some account of the "Pluvial Period"?

3. Where Hopkins's results on the power of water to move materials?

4. How does Mr. Tylor arrive at a velocity of *three times* excess of present velocity in paragraph four? McJAMES.

INDIA.

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## FOSSILS ON CLEAVAGE PLANES.

SIR,—Until I read Mr. Carruthers' article in the January Number of the GEOL. MAG. I had never realized how completely fossil plant remains might be simulated by annelid trails. To me, moreover, there was a special interest in the concluding sentence, which recalled to my mind an inquiry which I had been pursuing some two years ago. I was not then aware that the subject had been touched upon by Dr. Sterry Hunt, nor have I seen the paper by him to which Mr. Carruthers refers. I feel however disposed to call attention once more to the subject as it then presented itself to me. I must not reproduce remarks which have occupied more than two pages, nor do I see how I can well abridge them. But I will ask leave to refer Mr. Carruthers and the readers of his interesting article to a letter by me in the September (1880) Number of your MAGAZINE, pp. 430–2. It was there pointed out that not only "fucoids" (which might very probably have been annelid borings), but that *Graptolites also* had been found upon cleavage planes.

KENTISBEARE, COLLUMPTON. W. DOWNES.

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## DR. HECTOR'S "NEW ZEALAND GEOLOGY."

SIR,—I see in the January Number of this MAGAZINE a notice of the above Memoir, in which Dr. Hector classifies the Coal-producing strata of New South Wales as Permian. There has long been a dispute amongst Australian geologists as to the age of these deposits, many supposing them to be Triassic, or even Oolitic, presumedly upon the presence of *Glossopteris*; but it would be of interest to know Dr. Hector's reason for placing them amongst the Permian. In the many conversations which I have had with the late Rev. W. B. Clarke, F.R.S., upon the subject, he has invariably upheld their true Carboniferous age, and, as a field geologist who has had much experience amongst the Coal Fields of South Wales, Somersetshire, and New South Wales, I certainly cannot see much doubt on the subject. The Wianamatta Shales, noticeably in the Parramatta District, bear a close lithographical resemblance to the shales, clods, and clifts of the Gilfach-fargoed, and Mynyddyslwyn, Upper Carboniferous deposits of Glamorgan and Monmouthshire, and also contain obscure impressions, which certainly look like Stigmarian rootlets. The Hawkesbury Sandstone, which underlies the Wianamatta Shales, contains numerous cavities, especially at St. Leonard's, Sydney, which look very much as if they had been filled by Carpoliths, like the *Trigonocarpum* of the Pennant of South Wales and Somersetshire, and indeed bears a lithographical resemblance to that deposit. The Upper Marine Beds and Upper Coal-Measures of the Newcastle (N.S.W.) and Bulli Districts contain, besides *Glossopteris,* undoubted Sigillarian and

Stigmarian remains, and the Lower Marine Beds and Lower Coal-Measures of the Jamberoo and Saddleback Districts contain *Lepidodendron* and *Productus scabriculatus.* Specimens of the last-named Palliobranch, if I remember rightly, are in the Museum attached to the Mining Department, Sydney, to which institution I presented them in 1877. Locality, Jamberoo Mountains, Illawarra District, N.S.W. All these formations are conformable to each other, although in places unconformability exists, owing to unequal depositions in parts. My classification for the New South Wales Coal deposits is as follows:

| | |
|---|---|
| α. WIANAMATTA SHALES. (Mynyddyslwyn Series.) | Thin laminated shales, clods, and clifts. No workable coal. Obscure plant-remains. 600 ft. circum. |
| β. HAWKESBURY ROCKS. (Pennant Series.) | Fine whitish sandstones. No workable coal. Cavities of Carpoliths? 1300 ft. circ. |
| γ. UPPER MARINE BEDS. (Wenallt Series.) | Sandstones, chocolate-coloured shales, rich beds of clay-band iron ore, thin beds of limestones with Palliobranch, undetermined. Conglomerates with jasper, and blue and purple shales. No workable coal. 550 ft. circ. |
| δ. UPPER COAL MEASURES. (Rhondda Series.) | Shales and sandstones, workable coal and fire-clay. *Stigmaria*, *Sigillaria*, etc. 1200 ft. circ. |
| ε. LOWER MARINE BEDS. (Iron Ball Series of Merthyr, etc.) | Bands of limestones, clay-band iron ore. *Productus scabriculatus*, etc. No workable coal. 500 ft. circ. |
| ζ. LOWER COAL-MEASURES. (Ras Las Series.) | Sandstones, shales, workable coal, fire-clay. *Lepidodendron*, etc. 1800 ft. circ. |
| | Total thickness 5950 ft. circ. |

The Devonian formation, I believe, is largely represented in South Australia by the Mount Lofty and Hummuck Ranges, as well as by the Murrumbidgee deposits of N.S.W.; whilst the great mass of auriferous slates and sandstones of New South Wales, as well as those of Victoria, are undoubtedly Silurian.

ALFRED CRUTTWELL, F.G.S.

LONDON, *Feb. 15th*, 1882.

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## MISCELLANEOUS.

COAL IN SOUTH AFRICA.—We learn that various and prolific seams of anthracite and bituminous coal, some of them 10ft. or 12ft. in thickness, have been found in Natal, several being well adapted for locomotive and general steam purposes. That this coal is suitable for the former work has been proved by driving the locomotives of the existing railways for some hundreds of miles to and fro between Durban and Maritzburg. The possibility of using cheap local fuel instead of costly English coal in these distant colonies must give a great impetus to railway construction, and an extension beyond Ladysmith, in Natal, will provide a better and more expeditious highway to the Transvaal and Orange Free State. The Railway Bill for the expenditure of £5,000,000 upon railway construction in Cape Colony, which has just received the sanction of the Assembly at Cape Town, contemplates the intersection by a main line of the coal deposits of that colony. Therefore, after considerable delay, those coal-fields are now about to be placed in direct communication with both the coast and the Diamond Fields.—*English Mechanic*, etc.

# OBITUARY.

## SAMUEL SHARP, F.S.A., F.G.S.

BORN JULY 18th, 1814; DIED JANUARY 28th, 1882.

SAMUEL SHARP was born at Romsey in Hampshire, July 18th, 1814. He received his early education at a private school in Southsea, but owing to his father's death while he was still a boy, he removed with his family to Stamford in Lincolnshire. Mr. Sharp's stepfather was the proprietor and editor of the *Stamford Mercury*, the oldest and most widely circulated newspaper in the Midland Counties, and for some years Mr. Sharp assisted him in managing and editing this journal. From a very early age he had shown a taste for the study of science, especially Astronomy and Chemistry, and his attention appears to have been directed to the subject of Geology by a lecture delivered at Stamford by Mr. G. F. Richardson. Subsequently he had the advantage of studying the Oolitic districts around his home with Professor Morris, and other geologists, and gradually accumulated a large and valuable collection of fossils. In 1857, Mr. Sharp removed from Stamford, and went to live in the neighbourhood of Northampton. There he continued to collect largely from the Jurassic rocks, and his work was facilitated by the excavations then being carried on in all directions for raising the valuable iron-ore of the Northampton Sand. The general results of his observations on the district in which he lived were communicated to the Geological Society of London in two valuable papers on the Oolites of Northamptonshire, which were published in the Quarterly Journal. He wrote a little text-book, "The Rudiments of Geology," which has passed through two editions. As an Archæologist, Mr. Sharp was not less widely known than as a Geologist. On all questions of local antiquities he was one of the highest authorities in the Midland district, and many valuable papers relating to these subjects were contributed by him to the local journals. But it was as a Numismatist that Mr. Sharp especially distinguished himself. During the last thirty years he by unwearied exertions succeeded in bringing together an unrivalled collection illustrating the productions of the famous Stamford Mint. His valuable memoir on these interesting coins, with its several supplements, was published by the Numismatic Society, and constitutes the best authority on the subject. He laboured energetically to found a good provincial museum in the town of Northampton, and placed therein valuable contributions from his own large geological and antiquarian collections. Mr. Sharp was one of the most genial and hospitable of men, and was never happier than when contributing to the instruction and pleasure of others from the stores of knowledge which he had gradually acquired concerning the geology and antiquities of his adopted county. During his later years Mr. Sharp was precluded from active exertions in the field by feebleness and ill-health, but to the end he took a lively interest in the advance of our science. He died at Great Harrowden Hall on the 28th January, 1882, in his 68th year.—J. W. J.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE II. VOL. IX.

No. IV.—APRIL, 1882.

# ORIGINAL ARTICLES.

## I.—Contributions to the Palæontology of the Yorkshire Oolites.

By Wilfrid H. Hudleston, M.A., F.G.S., Pres.G.A.

### No. 2. *Gasteropoda of the Oxfordian and Lower Oolites.*

It was stated in the general introduction to these Contributions (Geol. Mag. June, 1880), that the divisions to be adopted would be regarded more as a matter of convenience than from any other point of view. It might, perhaps, seem more philosophical to have treated the whole of the Lower and Middle Oolites as one section of the subject *quâ* the Gasteropoda. By commencing at the base of the series the true sequence in time would have been followed, and the various "species" or their derivatives traced throughout. Had all the collections examined by me existed under one roof, this might have been practicable, as it would certainly have been desirable.

Again, it may seem somewhat odd, when drawing the line, to draw it through the very middle of the *perarmatus*-zone; but the fact is that from the Corallian to the very base of the Dogger no one line stands out very pre-eminent in a palæontological sense. Nor is there any very marked physical break other than what might result from a change of sediment between the top of the Cornbrash at Scarborough and the base of the Corallian Limestones (Passage-Beds). The palæontological break between the Cornbrash and the succeeding "Kelloway Rock," as regards *Cephalopoda*, is tolerably complete (see table), but not otherwise. There is a more marked discordance between the general fauna of the Cornbrash and of the Scarborough Limestone, which latter is in many respects allied with the two lowest zones.

On the whole, therefore, although the division adopted parts the Coral-bearing section of the zone of *A. perarmatus* from the rest, and thus adds a slice of quasi-Oxfordian Beds to the Corallian group, yet the additional species of Gasteropoda scored to the latter is so slight as scarcely to affect the lists. Even without such aid the Coralline Oolite and Coral Rag, *i.e.* the Upper Limestones of the Survey, afford a list of Gasteropoda not very far short of that produced by the aggregate of the beds below, whilst in numbers of individuals they infinitely exceed them. This arises in a great measure from the very limited vertical sections in the lower beds which yield Gasteropoda in recognizable condition.

One point of interest presented by the fine sections on the coast is the approximate position of the division between the Brown Jura

| FORMATION. | TOPOGRAPHICAL DIVISIONS AND VARIETIES. | LOCALITIES NOTED FOR FOSSIL |
|---|---|---|
| E.<br>LOWER CALCAREOUS GRIT.<br>80-100 ft. | Similar varieties occur in all the districts.<br>Thickens towards the interior.<br>ZONE 7 occurs in this series. | Oliver's Mount, Cayto Gristhorpe Cliffs, Castl ward Park. |
| F.<br>"OXFORD CLAY."<br>120-150 ft. on the coast. | Similar varieties occur in all the districts.<br>Thins towards the interior. About 70 ft. in the Howardian Hills.<br>ZONE 6 occurs at the base. | Scarborough Castle Gristhorpe Cliffs, Cu Nab (Newbiggan Wyke) |
| G.<br>"KELLOWAY ROCK."<br>5-80 ft. | ZONE 5 occurs at the top.<br>Thins on the dip towards the S.E., but rather increases along the outcrop towards the W.<br>Scarcely traceable in the Howardian Hills. | Scarborough North Cli Castle Hill, Red Cliff (C Bay), Newbiggan Wyke thorpe shore), Newtonda |
| H.<br>*Avicula*-shales and CORNBRASH.<br>10-15 ft. | Both thin on the dip, but maintain their thickness towards the west.<br>Not proved in the Howardian Hills.<br>ZONE 4 occurs at the base. | Scarborough North and Castle Hill, Red (Cayton Bay), Grist Cliffs. |
| *h*. Upper Estuarine Series. 80-200 ft. | | |
| I.<br>SCARBOROUGH or GREY LIMESTONE.<br>3-60 ft.<br>ZONE 3. | 1. Coast type.<br>Thins rapidly on the dip towards the S.E., tolerably constant towards the interior along the outcrops.<br>2. Howardian type. | 1. Cloughton Wyke ( dale), White Nab, Grist Bay.<br>2. Stonecliff Wood, Brandsby. |
| *i*. Middle Estuarine Series. 50-100 feet. | | |
| J.<br>MILLEPORE SERIES.<br>10-40 ft. on the coast.<br>ZONE 2. | 1. Coast type.<br>Thickens towards the S.E., variable in composition.<br>2. Howardian type, Whitwell Oolite, and Brandsby Beds in part. | 1. Cloughton Wyke (S ham), Yown Pt., and thorpe Scar.<br>2. Mount Pleasant Q near Castle Howard Stat |
| *j*. Lower Estuarine Series. ?-300 ft. | Attains its maximum in Staintondale Cliffs. | |
| K.<br>DOGGER.<br>4-80 ft. on the coast.<br>ZONE 1. | The "top seam" of the miners. The Rosedale magnetic ore belongs to the lower division. | Peak (Blue Wyke), Gl dale, Sandsend, High Wh Saltwick. |

in the Geol. Mag. Decade II. Vol. VII. p. 247.

THE WHOLE OF THE LOWER OOLITES.

| LITHOLOGY—REMARKS. | SOME OF THE CHARACTERISTIC FOSSILS. |
|---|---|
| 1. Hard blue calcareous grits—quarried for road metal—alternating with<br>2. Yellowish calcareous sand-rock, often full of small cavities—building stone. | *Bel. abbreviatus*, Mill. *Am. perarmatus*, Sow. *Am. cordatus* and *vertebralis*, Sow. *Am. convolutus*, Quens. *Am. canaliculatus*, Münst. *Gryphæa dilatata* and *Pinna lanceolata*, Sow. *Modiola bipartita*, Sow. *Astropecten rectus*, M'Coy. *Rhynch. Thurmanni*, Voltz. |
| Grey sandy shales and clays, becoming bluer and less sandy below. | UPPER—*Am. perarmatus*, rarely.<br>MIDDLE—Small Ammonites, young of *A. Eugenii*, Rasp., *A. crenatus*, Brug., etc.<br>LOWER—*Bel. Owenii*, Pratt. *Am. Lamberti*, Sow. *Am. athleta*, Phil. *Am. oculatus*, Phil. *Am. crenatus*, Brug.<br>Varieties of *A. cordatus* throughout. |
| The fossil beds, though only a few feet thick, are varied in their lithology. Reddish-yellow or chocolate grits with spathose shells and large ova: blue-grey and very sandy Calcareous Grits.<br>Brownish-yellow sandstones in the mass, quarried for building at Hackness. | *Bel. Owenii*, var. *tornatilis*, Phil. *Am. Jason*, Rein. *Am. Duncani*, Sow., and var. *gemmatus*, Phil.—the *ornati*. *Am. athleta*, Phil. *Am. hecticus*, and *lunula*, Rein. *Am. Chamusseti*, D'Orb. *Am. Gowerianus*, Sow. *Am. Kœnigi*, Sow. *Am. modiolaris*, Luid. *Am. macrocephalus*, Schlot. var. *rugosus*, Leck. *Gryphæa*, var. of *dilatata*, Sow. *Trig. paucicosta*, Lyc. *Anatina undulata*, Sow. *Wald. umbonella*, Lam. (near to *ornithocephala*, Sow.). |
| Blue shales passing upwards into yellow sandy mudstones.<br>Impure Limestone, grey and rubbly, partially oolitic, and sometimes stained reddish. | *Am. Herveyi*, Sow. (*macrocephalus*, Schlot.), the only cephalopod. *Lima rigidula*, Phil. *Avicula echinata*, Sow. *Trig. Scarburgensis*, Lyc. *Trig. elongata*, Sow. *Trig. Cassiope*, D'Orb. *Waldheimia obovata*, Sow. *W. lagenalis*, Schlot. *Rhynch. Leedsii*, Walk. (? *concinna*). *Echinobrissus orbicularis*, Phil. |
| False-bedded Sands and Clays. | *Anodon*. sp. A few plant remains. |
| 1. Blue and grey impure Limestones, shales, mudstones and ironstones, never oolitic. Roadstone, rough masonry (Scarboro' Pier).<br>2. Siliceous "potlid" Limestones. | 1. *Bel. giganteus*, Schlot. *Am. Humphresianus*, Sow. *Am. Blagdeni*, Sow. *Avicula Bramburiensis*, Phil. *Pteroperna plana*, M. and L. *Trig. costata* (var. *denticulata*), Ag. *Trig. signata*, Ag. Brachiopoda mostly absent. *Am.* "*læviusculus*" occurs at Hundale. |
| Sandstones and Shales, contains the main seams of moorland coal. | Dwarfed marine fossils sporadically. The "plant bed" is very rich in vegetable remains. |
| 1. At Sycarham a ferruginous grit, and sometimes a gritty irony lime rock with "Kaolinite."<br>2. Fawn-coloured sandy Limestone and Oolite, lower beds blue-centred. | 1. *Gervillia lata*, Phil. *Trig. recticosta*, Lyc. *Trig. conjungens*, Phil. *Ceromya Bajociana*, D'Orb. *Pygaster semisulcatus*, Phil. *Gonioseris angulata*, Dunc.<br>2. *Cardium Buckmani*, M. and L. *Isocardia cordata*, Buckm. *T. recticosta* and *conjungens*, *Pyg. semisulcatus*, and *Stom. germinans*, Phil. *Ter. submaxillata*, Dav. |
| Sandstones, often massive, and Shales. Building stones in Eskdale. | Traces of a marine horizon with *Pholadomya*, etc Numerous plant remains. |
| Arenaceous ironstone, in parts oolitic, resting on yellow and grey micaceous sands at Blue Wyke Point. | *Gervillia tortuosa*, Phil. *G. lata*, Phil. *Macrodon Hirsonensis*, D'Arch. *Trig. denticulata*, Ag. *Trig. v-costata*, Lyc., small var. *Trig. spinulosa*, Y. and B. *Cardium acutangulum*, Phil. *Astarte elegans*, Sow. *Ceromya Bajociana*, D Orb. *Rhynch. subobsoleta*, Dav.<br>In the sands *Am. aalensis*, Ziet. *Am. conmensis*, Von Buch. (*teste* Wright, Q.J.G.S. vol. xvi. p. 4). *Lingula Beanii*, Phil. *Discina reflexa*, Sow. *Rhynch. cynocephala*, Rich. *Ter. trilineata*, Y. and B. |

and White Jura of the Germans, or between what the Swiss geologists might term the "Dogger" and the "Malm." This line would probably run somewhere in the great unfossiliferous masses of the upper part of the "Oxford Clay." For further remarks on this subject, with reference to stratigraphical details and other matters, I must refer to the "Yorkshire Oolites."[1]

The distribution of the several zones which contain the Gasteropoda are more or less known to most geologists; yet I am persuaded to say a few words on this subject, partly to explain the accompanying table, and partly because, in spite of what has been written on the Geology of East Yorkshire, one is every now and then reminded that the mistakes of half a century ago possess a strange fascination for those who have but a cursory acquaintance with the district.

Although the beds below the Corallian probably exceed in the aggregate 1000 feet in thickness (taken at their *maxima*), yet the shelly horizons occupy but a limited space, and those which contain Gasteropoda in decent condition and quantity are still more limited. Adopting the coast sections in the main as our types, there are *seven* principal fossiliferous zones or horizons between the *striatulus*-beds —zone of *Ammonites Jurensis*—and the Corallian Rocks, whose Gasteropoda have been already described. (See Table on pp. 146-147.)

1. *First or lowest zone.* This is known as the DOGGER. Including the grey sands (*Lingula*-beds), the yellow sands, and the Dogger proper, a thickness of 80 feet may be assigned to the group, where most fully developed, as at Peak (Blue Wyke).[2] The remains of Gasteropoda are almost wholly confined to a shell-bed 18 inches thick, which occurs about 8 feet below the top of the series at Peak, but nowhere else in Yorkshire. The matrix is very characteristic. The substance of the shells has been largely replaced by spathic iron, whilst their exterior is lined with a thin skin of dark brown oxide. From the abundance of *Nerinæa cingenda* this band has been named the *Nerinæa*-bed. It contains nearly half the species enumerated in this Memoir (No. 2). Some 300 feet of "estuarine" sands and shales, with at best only irregular traces of marine shells, succeeds, and then we arrive at

2. *The second zone,* known as the MILLEPORE-BED, which is best seen on the north horn of Cloughton Wyke at Sycarham, where the thickness may be about 12 feet. This is also a kind of sandy ironstone, but more gritty and calcareous than the Dogger. The Gasteropoda are mostly limited to one bed, whilst Conchifera are abundant throughout. Some portions of the matrix contain more carbonate of iron than of lime, and there is just sufficient iron peroxidized to impart a reddish-brown tint to the mass, which is much flecked by a white substance allied to Kaolin. This peculiarity is less noticeable in the bed where the univalves are mostly found. The Millepore-Bed is well developed south of Scarborough, where it becomes thicker. It forms an important scar in Gristhorpe Bay. In the interior the fawn-coloured sandy limestones of the Howardian

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[1] Proc. Geol. Assoc. vols. iii. and iv.; see also Fox Strangways, Survey Mem. Geol. of Scarborough; and Wright, Quart. Journ. Geol. Soc. vol. xvi. p. 1 *et seq.*

[2] *Cf.* "*Yorkshire Oolites,*" part i. Proc. Geol. Assoc. vol. iii. p. 294.

Hills, worked in Whitwell parish and elsewhere, are referred to this horizon. North of Scarborough, on the coast, 100 ft. of "estuarine" sands and shales, containing the principal moorland coal and the celebrated plant-bed, intervene between the Millepore-Bed, and

3. *The third zone*, known as the SCARBOROUGH or GREY LIMESTONE. South of Scarborough these two zones approach, the Millepore Bed, as we have seen, becoming thicker, whilst the Scarborough Limestone in Gristhorpe Bay is reduced to a few feet, with every indication of going out altogether. Thus it is the Millepore-Bed which reappears further south as the Cave Oolite and the Lincolnshire Limestone. Near Scarborough, however, and especially north of that town, the uppermost of these two formations is far the most important. On the south horn of Cloughton Wyke, at Hundale, this group of beds has a thickness of nearly 60 feet, and contains a fine series of fossils, chiefly Conchifera. On the other side of Scarborough, at White Nab, the thickness has already fallen to 20 feet. It is here that specimens of *Am. Humphresianus* and *Blagdeni* have been found together with casts of a large *Chemnitzia* and *Phasianella*.[1] Lithologically this zone is composed for the most part of blue-grey limestones, more or less charged with dark-coloured mud, and in places is rich in iron. The fossils partake of this grey character, but there is a little difficulty sometimes in distinguishing specimens from certain varieties of the Millepore or Cornbrash. This is the least oolitic in structure of all the four zones of the Lower Oolites.

The three zones enumerated above belong to the Inferior or Bajocian subdivision of the Lower Oolites. The two lowest (*i.e.* the Dogger and the Millepore) are probably both in the *Murchisonæ* zone, the Millepore occupying the subzone of *Ammonites Sowerbyi*, though no ammonite has ever been found, to my knowledge, in beds of this horizon on the coast. The Scarborough Limestone, which distinctly dies out on the dip, must be regarded as on a level with the Coronaten-zone of the Germans. Above this comes a third "estuarine" series, which also thins considerably on the dip. As we have no palæontological indications in Yorkshire either of the *Parkinsoni*-zone,[2] or of the Great Oolite, it is not unreasonable to suppose that this third estuarine series may represent those formations in time. The gradual attenuation of the Great Oolite (Bathonian) in Lincolnshire[3] as a marine formation prepares us for this change. Doubtless the Yorkshire CORNBRASH must be regarded as the only representative of Bathonian beds in a palæontological sense, and this constitutes our

4. *Fourth zone*, only three or four feet thick at Scarborough, but extremely fossiliferous. It corresponds to part, at least, of Dr. Brauns' "Oolithischen mergel und eisenkalke mit *Avicula echinata*." The fossils from this bed are at once recognized by a peculiar waxy

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[1] For details of the sections at Hundale and White Nab see "Yorkshire Oolites," part i. Proc. Geol. Assoc. vol. iii. p. 312 *et seq.*

[2] *Am. Parkinsoni*, Sow., is quoted by Phillips from the "Grey Oolite" of White Nab, G.Y. third edition, p. 267, but I have never seen it in any collection.

[3] Judd, "Geology of Rutland," p. 10.

sort of calcite, which has been more favourable to the preservation of ornament than is usual in beds below the Corallian. The matrix may be described as a hard greyish marlstone, sometimes ferruginous and frequently flecked with large oolitic granules; sometimes it is stained red from peroxidation of the iron. Portions of this bed are a mass of spathic matter from the abundance of shells.

The so-called shales of the Cornbrash succeed, and these pass insensibly into the soft yellow base of the "Kelloway Rock," which, at Scarborough, and thence throughout the whole of the Tabular Hills to the western escarpment overlooking the central plain of Yorkshire, represents a huge sand bank at the base of the Oxfordian. Towards the upper part of this lies our

5. *Fifth zone* usually known as the KELLOWAY ROCK. Bivalves, especially *Trigonias*, are by no means uncommon in the middle portions of the Kelloway Rock, but the great shell beds in which alone recognizable Gasteropoda are found are always on the top. For further information relative to the Kelloway Rock I must again refer to the "Yorkshire Oolites."[1] (For some of the more characteristic Cephalopoda see table.) The matrix of these shell-beds is extremely variable, partly in consequence of atmospheric influences —so variable indeed that fossils from this horizon have puzzled and deceived many collectors. There is a bed of fine-grained calciferous sandstone for instance, called the chert bed by Mr. Leckenby, which yields fossils so similar in condition to those of the Lower Calcareous Grit in Cayton Bay, that only a very close inspection suffices to separate them. Another frequent matrix is an ochreous sandstone, a third a greyish ferruginous sandstone, in places stained red, and charged with large oolitic granules.

*Sixth zone.*—The lowest bed of the "OXFORD CLAY" of Scarborough Castle Hill contains numerous fossils (see table for some of the Cephalopods). It seems to have some relationship with a peculiar bed at Cunstone Nab (Gristhorpe) now concealed by a landslip, which yielded many varieties of Ammonites to Mr. Leckenby in a "thin band of calcareous pisolite," and which were always added to the score of the Kelloway Rock. As regards the bed to which I now refer, on Scarborough Castle Hill no specimens of the *ornati* are ever found in it. The fossils are not well preserved. There are numerous specimens of a *Perisphinctes* ammonite, whilst the *cordati* are represented by what is probably *Am. Lamberti*. *Am. oculatus* also occurs and several others. This may be regarded as the first of the Oxfordian zones which succeed the *ornatus*-beds. The rest of the Oxford Clay contains no definite shell-bed, and the upper portions are almost as devoid of shells as the sands of the estuarine series. This desert region may be regarded as the boundary between the Brown and the White Jura in Yorkshire.

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[1] "Kellaways Rock" of the Survey Memoir, "Kelloways Rock" of Phillips, "Kelloway Rock" of Leckenby. I prefer the latter name as individualizing a formation of greater importance and wider range in time than the bed which so inadequately represents it in Wiltshire.

[2] Proc. Geol. Soc. vol. iv. p. 364. *Cf.* also Leckenby, Q.J.G.S. 1858, p. 4 *et seq.*

*The seventh zone.*—In the Lower Calcareous Grit, except in the very lowest portions, fossils begin to occur more scattered about, but there is a calciferous or cherty band in Cayton Bay which contains well-preserved specimens of the ammonites mentioned in the table, together with bivalves and a very few Gasteropoda.

This completes the description of the zones or horizons from which the fossils forming the subject of Memoir No. 2 have been derived.

It must be conceded that the condition of many of these is by no means favourable to close determination. Moreover, differences of preservation due to the varied nature of the matrix have, I feel sure, exercised considerable influence on the external appearance of many of these shells, so that when a "species" wears a totally different dress, its identity is liable to be lost. Added to this is the further difficulty that some "species" have been founded on casts, without much regard to what might be the chances of the shell itself having been described by another author from a distant locality under a totally different aspect.

These and many other circumstances have tended to make the task of describing the Gasteropoda of the Lower beds a far more serious undertaking than was the case with the better preserved Corallian fossils described in the first Memoir. The usual difficulty of nomenclature is of course the most grievous, and one begins to recognize the fact that a fossil name is often little more than a label which enables the collector or curator to arrange his specimens in something like order. If there happens to be any mistake, such a mistake is likely to be handed down to posterity for an indefinite period. For example, *Natica cincta*, Phil., an Inferior Oolite fossil, was accidentally classed by Phillips in the Coralline Oolite, and has been so quoted by most palæontologists. One can easily believe that for a hundred years to come it will be quoted in some places as a Corallian fossil. It is easier to make a new rope than to straighten one that has got a kink.

With such materials and under such conditions it is not to be expected that, in selecting names for a fossil, those most appropriate in a biological sense should always be available. Indeed, it is not seldom more difficult to locate a specimen generically than specifically—witness the perpetual shifting from one genus to another of certain familiar species. Provisionally, in some of these cases, it might save trouble to adopt the genus of the founder of the species.

In concluding these introductory remarks, I would observe that Gasteropoda bear an extremely small proportion to other Mollusca in the beds under consideration. A collector may amass a considerable number of specimens of all sorts before he obtains any univalves fit for figuring. Nor are they so useful in determining horizons as the Cephalopoda, for instance, since they seem to have been more influenced by "conditions," and are thus less reliable as indicators of time.

My best thanks are due to the authorities at Cambridge, York, the British Museum, and Jermyn Street for the facilities and assistance afforded.

(*To be continued in our next Number.*)

## II.—SOME POINTS IN THE GEOLOGY OF ANGLESEY.

By R. D. ROBERTS, M.A., D.Sc., F.G.S.;
Clare College, Cambridge.

I REGRET that in consequence of the omission of a correction in my letter (GEOL. MAG. Dec. 1881), I represented Dr. Callaway as stating that the Nebo rock was *granitoidite* instead of a part of the *granitoidite series.* When the letter was written, I was not able to refer to Dr. Callaway's paper for his exact words, and on seeing the paper two or three days later, and finding that I had not given accurately the words, I wrote at once to the Editor of the GEOLOGICAL MAGAZINE, asking him to substitute for the word "granitoidite" the words "Pre-Cambrian rock." By inadvertence this was not done, and as proofs of letters are not usually sent to authors for correction, I found that the alteration had not been made when the December MAGAZINE appeared. Admitting this verbal inaccuracy, my argument however is not affected.

Dr. Callaway's words in the paper referred to (GEOL. MAG. 1880, p. 118) are as follows: "As confirming the identity of the Anglesey and Twt Hill granitoidite the following fact is of importance. Messrs. Bonney and Houghton have detected at Twt Hill a passage between the granitoidite and a quartzose conglomerate with a south-east dip. I have visited this section, and, having examined the rock inch by inch, I can entirely confirm their identification. There are no signs of a fault between the granitoidite and the conglomerate, and the transition between the two is gradual and unbroken. I have had the good fortune to discover this identical conglomerate in Anglesey. It is exposed in two quarries near Nebo two miles south-west of Amlwch, dipping to the north-west at a high angle. Lithologically it is perfectly indistinguishable from the Twt Hill rock; the quartz has the same glazed surface, both conglomerates contain disseminated crystals of cubic pyrites and are tinged with the same dingy purple colour. I could find no granitoid rock in these quarries, but the ordinary granitoidite occurs on about the same strike one-third of a mile to the north-east. That this conglomerate is not Cambrian or Ordovician is proved by the fact that in these quarries black Ordovician (Caradoc or older) shales rest on its upturned edges. It is also associated with bands of quartzose grit as in the Twt Hill locality."

Dr. Callaway's position is clearly this:

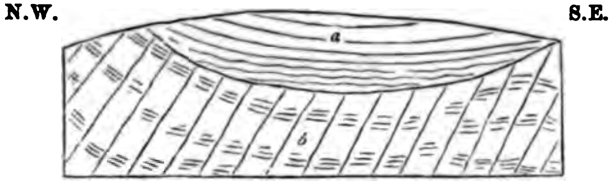
1. He believes that there is an unbroken transition between the quartz conglomerate and the granitoidite at Twt Hill. In other words that the Twt Hill quartz conglomerate is a part of the granitoidite series.
2. He identifies the quartz conglomerate and grit at Nebo with the quartz conglomerate at Twt Hill by their lithological character.
3. He concludes that the quartz conglomerate at Nebo is Archæan, and a part of the granitoidite series, because black Ordovician shales rest against and on it, as he believes, unconformably.

I have contended as follows:—1. That the Twt Hill quartz conglomerate is the basement bed of the Cambrian resting against the Pre-Cambrian granitoid basis.

2. I also identify the quartz conglomerate at Twt Hill with that at Nebo.

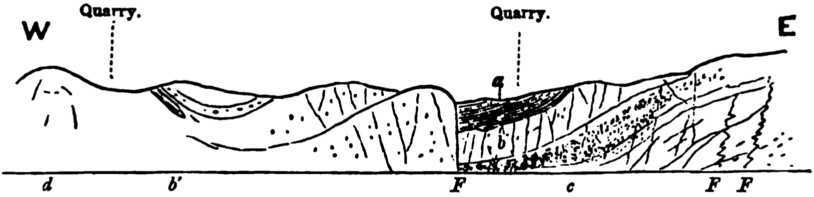
3. I hold that the disagreement in dip of the conglomerate and shales, in the northern quarry at Nebo, is due to a fault, as shown in Fig. 3 in my paper (Geol. Mag. 1881, p. 197). The discordancy between the shales and conglomerate in the other or lower quarry of Dr. Callaway is due to the crushing of the conformable overlying shale during the movements of the underlying unyielding grits, but the apparent unconformity indicated by Dr. Callaway in his section (Q. J. G. S. vol. xxxvii. 1881, pl. viii. fig. 6) does not exist. The divisional planes which he takes for bedding are joints approximately parallel to the fault. To make this clear I give a copy of Dr. Callaway's section, Fig. 1, and my own section of the same quarry, Fig. 2.

Fig. 1. Section across Lower (Southern) Quarry, S. of Nebo, Anglesey. Dr. Callaway's Section (Q. G. J. S. vol. xxxvii. pl. viii. fig. 6[*]).



*a* = Cambrian shales. *b* = Cambrian grit (called by Dr. Callaway Pre-Cambrian).

Fig. 2. Section across lower (Southern) Quarry, S. of Nebo, Anglesey. Dr. Roberts's Section.



*a*. Black slate much crushed = Cambrian shales.
*b* = Cambrian grit (called by Dr. Callaway Pre-Cambrian).
*b'*. Black slate and subordinate sandstone.
*c*. Veined and jointed grits, conglomeratic in parts.
*d* = Dyke. *F F* = Faults.

The points at issue must now, I think, be perfectly clear.

Dr. Callaway (Geol. Mag. Feb. 1882, p. 57) says, referring to my criticism, "I have always been perfectly aware that the black shale is faulted against the grit. Indeed, in my note-book I find a section (dated July 20, 1880) which is almost a facsimile of the figure in Dr. Roberts's paper." He then adds that his view is that the shales were both unconformable and faulted. I have quoted in an earlier part of this communication Dr. Callaway's description of this section, and it contains no single word about faulting. Nor does his paper (Q. J. G. S. vol. xxxvii. p. 220), in which he refers to the same sections. It is much to be regretted that Dr. Callaway did not publish the section in his private note-book, "which is almost a *facsimile*" of mine, and which he admits to be a faithful representation of the facts, instead of the inaccurate and misleading sections given in his paper just referred to. The case then stands as follows: Black shales and a quartz conglomerate are shown in juxtaposition in two quarries, near Nebo. Dr. Callaway has asserted that they are unconformable, and has based upon that certain arguments. In the northern or upper quarry he now admits that there is a fault, while in the southern or lower quarry (Fig. 2) he has, according to my interpretation, mistaken joints for bedding; the base of the crushed shales as a matter of fact coinciding in direction with the bedding of the conglomerate.

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[*] In Dr. Callaway's Plate, the *upper bed a* is marked "*c* = Cambrian?"; and the *lower bed* is marked "*a* = Gneissic series," "fig. 6, *c* on *a*."

In concluding I may just observe that Professor Bonney no longer holds the view which Dr. Callaway so strongly supports in the first quoted paragraph, namely, that the Twt Hill conglomerate is a part of the granitoidite series. Does Dr. Callaway still adhere to this view?

The last point in Dr. Callaway's paper as to felsite pebbles I pass over, inasmuch as I have dealt fully with that matter in my reply to Prof. Bonney.

In the foregoing I have not touched upon the metamorphic rocks of Anglesey, to which a considerable part of Dr. Callaway's paper is devoted. That is a subject in no way connected with the matters treated of in this paper, and I leave it for another communication.

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## III.—NOTES ON SOME FOSSILS FROM THE RED BEDS OF THE LOWER DEVONIAN, TORQUAY, SOUTH DEVON.

By ROBERT ETHERIDGE, F.R.S., F.G.S., etc.

(PLATE IV. Figs. 4—11.)

MR. A. CHAMPERNOWNE having requested me to examine and briefly notice some fossils in his collection, obtained from the Red Homalonotus Beds of the Lower Devonian, Torquay, I have endeavoured to comply with his request so far as the condition of the specimens permits. Besides the *Homalonotus* remains, there are a number of Mollusca preserved as casts, but, for the most part, so distorted by slaty cleavage, as to render their determination most difficult.

The following remarks on the probable affinities of the fossils figured on Plate IV. may, it is hoped, induce other collectors to examine the beds frow whence they were obtained, and so lead to the discovery of more perfectly preserved specimens.

### LAMELLIBRANCHIATA.

1. *Cypricardia lævisulcus*, Eth. sp. nov. (Pl. IV. Figs. 4 and 5.)

There appear to be two genera of Bivalve Mollusca represented here, namely, *Cypricardia* and *Modiolopsis;* the former might be a

*Sanguinolites* distorted through pressure at the umbones, but the posterior side seems to show the ridge which characterizes *Cypricardia;* the sharply defined concentric ridges, or lines of growth, and the depressed umbones, are sufficiently clear to enable me, with other characters, to refer it to the latter genus. The smooth deep concave depressions between the sharp elevated lines of growth are highly characteristic of *Cypricardia* and *Cypricardites.* I therefore refer Figs. 4 and 5, Plate IV. to *Cypricardia.*

I know no British or foreign Devonian species to which I can refer it. A convenient name would be *Cypricardia lævisulcus.* This cast somewhat resembles *Orthonota* (*Cypricardia*) *semisulcata,* Sow. (Phillips, Pal. Foss. Dev. and Cornw. tab. 17, fig. 57), but is a much larger shell, and probably the concentric ridges are sharper. There is no appearance of the transverse furrows on the posterior side, nor of the intermediate shorter ones mentioned by Phillips. The fossil may, however, be referred to *Cypricardia* without doubt.

*Loc. and Formation.*—Lr. Devonian, Smuggler's Cove, Torquay.

### 2. *Modiolopsis* sp. (Pl. IV. Fig. 6.)

It is probable that Fig. 6 is only a portion of a much more elongated shell resembling posteriorly an *Anodonta* or *Sanguinolaria.* I was at first inclined to the opinion that this specimen might prove to be allied to *Myalina,* which occurs in the Middle Devonian of Exmoor, but I cannot detect the carina or ridge which characterizes some of the *Mytili* and *Dreissenæ.* The nearest approach to this fossil will be found in the genus *Modiolopsis.*

The shell was evidently thin, elongated, and inequilateral, and the hinge-area more or less straight (the ventral margin is not seen); the posterior end was wider, probably, and higher than the anterior, or much expanded.

No trace exists on the fossil of ornamentation or sculpture save broad undulating fold-like lines of growth. A smaller specimen, not figured, belonging to the same species, shows the straight hinge-line as seen in *Modiolopsis* and *Modiola.* The folds on the sides of the shell are too coarse and undulating for *Edmondia,* nevertheless there is much in common with that genus in the smaller unfigured specimen.

As no sufficiently well-marked specific characters can be detected by which to distinguish this fossil, it would be unwise to append any specific name.

*Formation and Locality.*—From the Lincombe Grits, New Cut, Torquay.

Collection of A. Champernowne, Esq., F.G.S.

## BRACHIOPODA.

### 3. *Spirifera cultrijugata?* Röm. (Pl. IV. Fig. 9.)

This fossil, which is only an internal cast, is in so unsatisfactory a state as to forbid accurate determination. It must either be referred to *Spirifera cultrijugata* or *S. disjuncta.* Careful specific determination from such imperfect materials is hardly to be hoped for, or desired.

*Sp. cultrijugata* occurs in the Middle Devonian of the Eifel, and has, according to Dr. Thos. Davidson, F.R.S., some resemblance to *Sp. socialis* from the Devonian of Menzenberg. Not the faintest indication of ribs is observable on the specimen figured.

*Formation and Locality.*—Middle? Devonian Slates, Smuggler's Cove, Torquay.

### 4. *Rhynchonella laticosta?* Dav. (Pl. IV. Fig. 7.)

Notwithstanding the imperfect state of preservation of this specimen, there can be little doubt in referring it to the species indicated. Not a single perfect specimen of *Rh. laticosta* has occurred to Dr. Davidson's careful researches, all the examples known to him being crushed and contorted; no specimen with the shell preserved has as yet been discovered in the British Devonian rocks.

The specimen figured (Fig. 7) is distorted in length through imperfect slaty-cleavage, and is therefore all the more difficult to determine satisfactorily.

Probably from 15 to 20 costæ ornamented the surface of the valves, but a portion of the specimen lies hidden beneath the matrix.

*Rh. Pengelliana* much resembles our specimen, but appears to have more costæ.

*Formation and Locality.*—From the Lower Devonian of Smuggler's Cove, near Torquay.

### 5. *O. hipparionix*, vel *Orthis striatula.* (Pl. IV. Fig. 8.)

I infer from the numerous fine costæ seen at the ventral edge of Fig. 8, as well as from the muscular impressions, that this fossil may be correctly referred to one of the above-named species, most probably to *O. hipparionix.*

The costæ are coarser than are those of *O. striatula,* and the muscular scars agree better with *O. hipparionix.* The costæ on the frontal margin are coarser than those upon the lateral portion of the valves.

It must, however, always be borne in mind that these are only casts, and they do not therefore often afford satisfactory characters upon which to found specific determinations.

*Formation and Locality.*—The same as the foregoing.

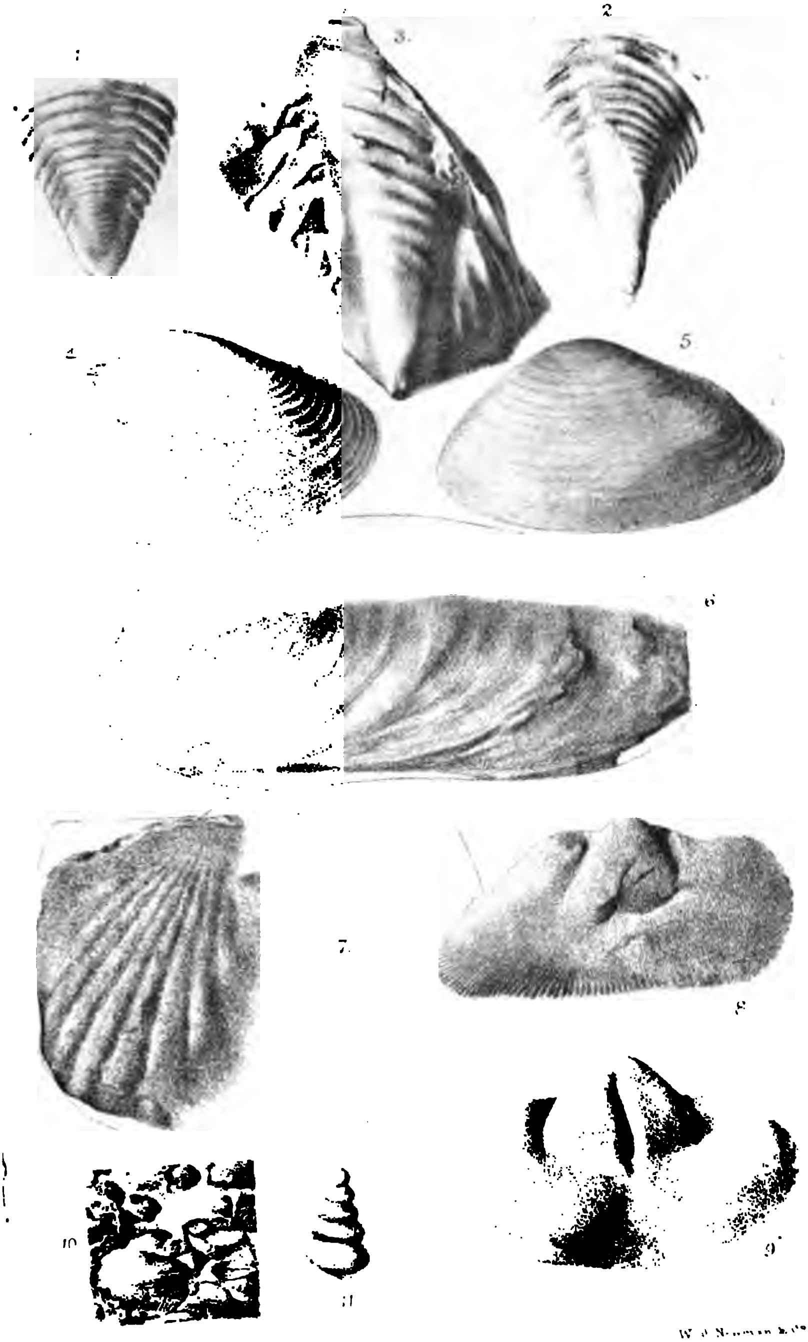
### 6. *Chonetes sordida.* (Pl. IV. Fig. 10.)

Numerous specimens of *Chonetes sordida* occur in Mr. Champernowne's collection.

I do not think this form can be referred to the *Ch. Hardrensis* of Phillips. No spines are observable along the hinge-line, and the hinge-area is less than in the true *C. Hardrensis*; the valve is also deeper.

Fig. 10 represents a portion of the surface of a slab, of dense fine-grained sandstone three inches square, completely covered with this shell.

*Loc. and Formation* as in the preceding.



G. M. Woodward del. et lith.

W. [illegible] Newman & Co.

*Devonian Fossils from Torquay.*

### GASTEROPODA.

#### 7. *Loxonema ? sp.* (Pl. IV. Fig. 11.)

This is merely a cast of a spiral Gasteropod resembling *Loxonema* (or an elongated form of *Holopella* from the Upper Silurian). It is probably safest to refer it to *Loxonema*. It occurs in the same bed with *Chonetes sordida.*

The only object in figuring these casts is in order to show the associated fossils contained in certain beds in the Lower Devonian slates near Torquay, S. Devon. Even such imperfect materials become of value for purposes of comparison and correlation with the Devonians of North Devon and the Eifel. R.E.

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## IV.—ADDITIONAL NOTE ON *HOMALONOTUS* FROM THE DEVONIAN.

By HENRY WOODWARD, LL.D., F.R.S., F.G.S.

(PLATE IV. Figs. 1, 2, 3.)

IN the GEOLOGICAL MAGAZINE, November, 1881, I published a brief description, accompanied by a Plate, of a new species of spinose *Homalonotus*, which I named after its discoverer, *H. Champernownei.*

On the accompanying Plate IV. Fig. 3, I have given an illustration of the tail probably referable to the above-named species.

The specimen gives evidence in the axis of about twelve coalesced caudal rings, the anterior of which were ornamented with a double row of spines. The extremity of the pygidium is produced into a blunt robust spine or mucro, which was probably considerably longer than the specimen now shows it to be, being only preserved as a cast.

The axis of the caudal shield is narrow and strongly annulated, save the last eight lines, which are smooth and somewhat more contracted, the axis diminishing from ten lines in breadth in front, to five lines near the hinder part of the shield. The side ribs are about six in number, and fade gradually away near the margin, which is smooth and slightly elevated.

The specimen is much distorted by slaty cleavage.

*Formation and Locality.*—From the Red Homalonotus bed, top of the Lower Devonian, New Cut, Torquay.

Collection of A. Champernowne, Esq., M.A., F.G.S., Dartington Hall, Totnes, Devon.

The specimen (Fig. 1) on our Plate represents a tail of *Homalonotus*, obtained by E. B. Tawney, Esq., M.A., F.G.S., from Smuggler's Cove, Torquay, S. Devon. This pygidium is very distinct in form from the preceding one. It measures 11 lines in breadth at its proximal border, and 12½ lines in length.

The axis is very broad in proportion to the lateral portions, and the division between them is but slight.

Breadth of axis at proximal border 6 lines. It is composed of from 12 to 13 annuli or coalesced caudal rings, the corrugations of which are slightly bent downwards on each side, and continued to the border of the pygidium as well-developed side ribs. The costæ diminish in size and strength from the proximal border till they disappear near the hinder part of the axis about 4½ lines from the extremity, which is smooth, or nearly so. There are no spines or other ornamentation on the surface of this specimen.

This pygidium agrees most nearly in character with *Homalonotus Knightii* from the Upper Silurian (Ludlow Rock); but our specimen is somewhat narrower in proportion to its length, and has more numerous costæ than its Upper Silurian predecessor, to which however it is clearly related. From the angular form of the ribs and the contour of the tail, this specimen may be named *Homalonotus goniopygæus.*

*Formation and Locality*—Middle or Lower Devonian, Smuggler's Cove, Torquay.

Collected by E. B. Tawney, Esq., M.A., F.G.S.

The third and last specimen of *Homalonotus* (Fig. 2) is from the collection of Mr. John Edward Lee, F.S.A., F.G.S., Villa Syracusa, Torquay, and was obtained by him from the Meadsfoot Shale, Ord's Bay, opposite the Thatcher. It affords evidence of the presence of a species of *Homalonotus*, but is, I regret, too imperfect for specific description.

### EXPLANATION OF PLATE IV.

Fig. 1. *Homalonotus goniopygæus*, H.W. Smuggler's Cove, Torquay.
„ 2. „ sp. indet. Meadsfoot Beds, opposite the Thatcher.
„ 3. „ *Champernownei ?* H.W. Red Beds, New Cut, Torquay.
„ 4. & 5. *Cypricardia lævisulcus*, Etheridge sp. nov.
„ 6. *Modiolopsis*, sp. ?
„ 7. *Rhynchonella laticosta ?*
„ 8. *Orthis hipparionix ?*
„ 9. *Spirifera cultrijugata*, Rom.
„ 10. *Chonetes sordida.*
„ 11. *Loxonema*, sp. ?

Figs. 3—11 are all from the Lower Devonian Red Homalonotus Beds, New Cut, Torquay, and are in the Collection of A. Champernowne, Esq., M.A., F.G.S.

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## V.—On the Classification of the European Rocks known as Permian and Trias.

By the Rev. A. Irving, B.Sc., B.A., F.G.S.;
Senior Science Master of Wellington College.

As this subject has been a matter for considerable debate during the past few years, and the British Committee of the International Geological Congress have had the matter under their consideration, it may be useful if I attempt to place before the readers of the Geological Magazine the results of the investigations of our sub-committee.[1] As is well known, the term "Poikilitic" has been proposed in some quarters as a comprehensive name for both series, some writers advocating the view that they ought to be regarded as one "system," as indeed they were of old under the name "New Red Sandstone." The palæontological evidence, however, against this is strong, and much stronger in Germany than in Britain. In the former country there is a definitely marked system below the *Trias*, commonly known as *Dyas*, from the fact that it is made up of two well-defined "formations." The late Sir Roderick I. Murchison was mainly instrumental in separating the lower members from the upper of the series formerly known as the "New Red Sandstone"; but his application to the former of the term "Permian" was scarcely felicitous. He would have done better to have taken the Dyassic system of Germany as a type, instead of the Russian series, for these reasons:—1. They are more sharply defined; 2. They have had an amount of labour bestowed upon them beyond all comparison greater than that which has been bestowed upon the Russian series. Murchison's method of procedure was arbitrary, and has been productive of much confusion. I say this from conviction, and not from any lack of reverence for the memory of so great a master. He made a hasty, and necessarily imperfect, inspection (it could hardly be called a "survey") of a series of strata which occupies fully one-half of the Russian European territory; he then took upon himself to apply his conclusions, drawn from what he observed in the Russian series, to correct (as he thought) the Dyassic classification of German geologists, on grounds, the value of which we shall have to look into presently; and having constructed, according to his own notion, a "Palæozoic Trias" in place of the established Dyassic system, he proceeded to apply this to the English strata, and to construct, entirely (so far as I can see) on *à priori* grounds, *a tripartite Permian System for the British Area.*

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[1] It must be understood that the sub-committee is in no way collectively responsible for any of the statements made in this paper.

Now, in a discussion some time ago at the Geological Society of London,[1] I find Professor T. McKenny Hughes maintaining that many of the so-called Permians were only "stained Carboniferous; that the fossil lists had been founded on a wrong classification, which had not yet been set right; that the Permian system must be broken up, and part given back to the Lower New Red and Magnesian Limestone system previously so well established, and part to the Carboniferous." Mr. J. J. Harris Teall, M.A., F.G.S., expressed to me his opinion that the description of the Permian series of Russia, contained in Murchison's *Geology of Russia and the Ural Mountains*, points to what Sir A. Ramsay calls "continental" conditions, and is directly applicable to our Permian and Triassic systems *taken as a whole.* The same gentleman urges strongly the view that rocks deposited conformably upon, and in contiguity with, Coal-measures in this country ought not to be called Permian; and that any classification which has the effect of obscuring the marked break between the Carboniferous and the Poikilitic (Permian and Trias) systems is unnatural, and should therefore be given up.

The space in geological time which this great series of strata intervening between the Carboniferous and Jurassic systems represents is enormous. Mere adding together of the *maxima* of the deposits gives only a rough approximation; so many circumstances which affect the rate of denudation, and therefore of deposition, have to be taken into account. If, moreover, we take, with Prof. Ball,[1] "a glimpse through the corridors of time," and are convinced even a little by his arguments, we must make some allowance for the disparity between the work of the tidal wave now and in the remote past, even within the limits of the geological record, and therefore be cautious in drawing inferences as to duration of time in a great series made up largely of shore-, bay-, and lagoon-formations. It is in their fauna and flora, and the enormous contrast which they present at the close of the Carboniferous to what is found at the close of the Triassic age, that we get something like trustworthy data from which to reason. But neither on palæontological nor on stratigraphical grounds can we take the fragmentary and fringing strata of the series as they occur in Britain for the basis of such a calculation. In the words of Prof. Credner, of Leipzig:[2] "Since the more complete investigation of the Alpine Trias, we have learnt to recognize formations of a remarkably similar facies (partly with identical species) in Sierra Nevada (California), in Spitzbergen, in N. Siberia, in New Zealand, and in the Himalaya. It appears therefore that the Alpine facies of the Trias is not, as was supposed, a special and local production, but rather the *essential, peculiar, and normal representative of the Triassic marine deposits.* The German Trias, on the other hand, is not the typical and truly proportionate facies, but is merely local, consisting of shore-, bay-, and lagoon-structures. The Alpine Trias and the German or English Trias are related therefore much the same as the Carboniferous Limestone to the Culm, or the Devonian proper to the Old Red Sandstone." In the Alps the Permian strata are scarcely, if at all, represented; it is in the middle of Germany, in Thüringia, in Saxony, and in the country which lies to the south of the Harz Mountains, that we must look for their typical development.

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[1] *Vide* Quart. Journ. Geol. Soc. vol. xxx.

The real question at present under discussion among English geologists is: What shall be done with the Permian series? There seem to be insuperable objections to classing them with the Trias, in spite of some lithological relation subsisting between the two series, and of the fact that they are in places stratigraphically conformable to one another. In Germany, where the palæontological distinction is the most pronounced, the graduation from the Dyas upwards into the Trias is most complete; a fact which Murchison fully recognized years ago.[3] The following is Credner's classification of the whole series:—

| | |
|---|---|
| TRIAS | 3. KEUPER: a formation of marls, sandstone, and gypsum, with land-plant remains. |
| | 2. MUSCHELKALK: a calcareous formation with remains of marine fauna. |
| | 1. BUNTER SANDSTEIN: a shore formation with land-plant remains. |
| DYAS. | 2. ZECHSTEIN-GROUP: a formation of limestone, dolomite, and gypsum, with remains of marine fauna ("*Kupferschiefer*" as a base). |
| | 1. ROTHLIEGENDE: a formation of conglomerates, and sandstones, with remains of a land-flora. |

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[1] *Vide Nature*, Nos. 630, 631. A lecture by Prof. Robert S. Ball, LL.D., F.R.S.

[2] *Elemente der Geologie*, Leipzig, 1876 (p. 352).

[3] *Vide Siluria*, also a paper by Murchison and Morris, Q. J. G. S., vol. xi.

The formations included in the Dyas are, he remarks, "two series of strata sharply distinguished from each other both petrographically and palæontologically." This would probably have been accepted as the normal order of things in Europe, had it not been for the way in which Murchison forced his views upon people, for which he met during his lifetime with a well-merited rebuke from a foreigner, M. Marcou.[1] The clear and masterly description of the German series, and the comparison of it with those of England, Russia, the Alps and North America, is worth any effort that may be required to read what Credner has written on the subject. A great deal of information may also be obtained from the two writings of Murchison's to which reference has been made already: they ought to be read by every student of this subject, for they contain a mine of facts; but the arguments by which these facts are made subservient to foregone conclusions need analyzing. We must premise here the note that the Permians of Russia do not admit of any exact parallelism petrographically with the Dyas of Germany; there is no division into an *upper* limestone- dolomite-gypsum- formation with remains of a marine fauna, such as we have in the Zechstein, and a *lower* sandstone- conglomerate- marl-formation with remains of land-plants, such as is found in the Rothliegende. On the contrary, the limestones and dolomites of the Russian series are repeated over and over again through nearly its whole range; but upon the whole the marine deposits are subordinated to the sandstones, marls, and conglomerates. Let us now see how Murchison set to work to upset the classification adopted in Germany.

1. He points out that in some districts of Germany, and in particular in the vicinity of Eisenach, where sub-atmospheric erosion has carved the country into deep valleys and ravines, the hills composed of Dyassic strata are capped by certain strata to which he refers under the name of "Bunter-schiefer." These are comprehended in the lower division of the Bunter formation by German geologists. But, No, says Murchison, they form the *natural* capping of the hills, and I claim them for the Permian, and group them with the rocks on which they lie. Now this surely is not proof. The word "natural" expresses only personal conviction; and against the conviction of one or two English writers on this point we have to set the unanimous conviction of a host of German geologists, in whose opinion the strata in question belong just as "naturally" to the Bunter Sandstein, at the base of which they lie quite conformably, to which also they are lithologically allied.

2. Murchison argues from the fact that in the Permian series of Russia the marls and sandstones which *overlie* the uppermost dolomite deposits contain remains of land-plants and of Protosaurians of species identical with some found in Germany in the Rothliegende *below* the Zechstein. His argument, when stripped of rhetoric, comes to this: such and such remains are found in Germany below,

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[1] *Vide Lettres sur les Roches du Jura*, par Jules Marcou, Paris, 1860.

and in Russia above, the dolomitic strata, therefore they *ought to be found* in certain strata which in Germany lie above the Zechstein; true, they are not found there at present, but since they ought to be, we will call these strata Permian, if you please. Further research does not seem to have verified this exercise of the prophetic instinct.

3. A great deal is made of the fact that specimens of a certain equisetaceous plant are found in the "Bunter Schiefer." This is quoted as *Calamites "arenarius"* (more correctly *C. arenaceus*). Now, since *Calamites* is a recognized Palæozoic type of plant-life, it is argued that therefore the rocks of this horizon in Germany must be considered Palæozoic, and therefore Permian. Good authorities, however, are doubtful if these are really specimens of *Calamites* at all; such high authorities as Mr. Etheridge and Prof. Morris have expressed their doubts to me on this subject. But, even if this preliminary question were to be answered in the affirmative, it remains to be shown beyond a doubt that the specimens found were *not derivative.* The genera *Pecopteris* and *Tæniopteris*, undoubted Carboniferous forms, are found high up in the German Trias; yet no one would think of establishing on such evidence a close relationship between the Trias and the Carboniferous.

It is no wonder that such special pleading failed to convert the German school to the Murchisonian creed. The views thus propounded found, however, readier acceptance in England, notwithstanding the *primâ facie* objection, which must have occurred to many, to adopting as the type of the series the form in which it is developed in the most inaccessible parts of Europe. It was adopted by Professor Hull in a paper read by him before the Geological Society of London.[1] In this paper the author appears to consider the absence, as he thought, of the Lower Bunter from the Odenwald district, to which the paper chiefly refers, as evidence in favour of the Permian classification adopted by Murchison. A reference, however, to Credner's text-book (p. 494) shows that more recent examination of that district has filled up the gap which Prof. Hull supposed to exist there.

In *Siluria* there is much vague talk about the tripartite division of the Permian; such a division is assumed to exist in Germany, and it is argued therefore that it must hold good in English geology. The author of the theory proceeds then to apply it to our English rocks, without, so far as I can see, adducing any evidence in support of it *from facts observed in the English rocks.* In a paper read by him before the Geological Society[2] he manipulates the observations of Prof. Harkness on the rocks of the Eden Valley, and on purely theoretical grounds overrides the previous judgment of that able geologist. In a paper some two years previous to the appearance of Murchison's, to which reference is now made, Prof. Harkness[3] had expressed the opinion that the great group of sandstones known as the "St. Bee's Sandstone" had more Triassic than Permian affinities, and that it ought to be relegated to the Triassic system. Murchison

[1] *Vide* Q. J. G. S. vol. xiv.

[2] *Vide* Q.J.G.S. vol. xx.

[3] *Ibid*, vol. xviii.

takes the contrary view, and calls these rocks Permian, in order to make the Edenside rocks harmonize with his system. More recent and detailed examination of these rocks has led to the adoption of Harkness's views on this matter, and to the rejection of Murchison's. Mr. J. H. Goodchild, who has worked at the systematic survey of these rocks, writes to me: "My own idea is that Sedgwick was right in putting the St. Bee's sandstone and the shales that form its natural base in the set of rocks which we have to call Trias. Phillips and Harkness, and may be others, followed Sedgwick in putting the beds above the Magnesian Limestone of the Eden Valley in with the 'Trias'; and it was only because Murchison thought there ought to be an unconformity between the Permian and Trias, and he could find no evidence of unconformity in our Edenside rocks, that he took upon himself to put the upper half of them into the Permian." Possessed by the notion that symmetry in classification was gained by introducing the notion of a "Palæozoic Trias" as well as a Mesozoic one, the facts exhibited in the rocks themselves were expected to conform to theory; if not, so much the worse for the facts. (How different this from the almost excessive caution of our other great master Lyell, now, like Murchison, numbered among the honourable ones of the past whose work still lives!) The classification put forward by Murchison still finds favour in some quarters; and quite recently so high an authority as Prof. Hull has proposed it for the acceptance of the British Committee. We must therefore inquire further, but briefly, how far such views have been confirmed by recent observations in other areas than the Vale of Eden.

(*a*) In the north-eastern area, Notts, Yorkshire, and Durham. Here, as in the north-west, certain thick-bedded sandstones, with included breccias, are found at the base of the Lower Mottled Sandstone of the Bunter. In deference to so high an authority as Sir R. I. Murchison, I was myself, in common with some other observers, misled as to these beds; and in consequence argued, from what was observed in Nottinghamshire, that there was something like a gradation upwards of the Permian rocks into the Trias in that district. In the new edition of Mr. Aveline's "Memoir on the Geology of the Country around Nottingham," these particular rocks are included with the Bunter series, and good reasons are given for this being done. Mr. Aveline quotes the opinion of Mr. E. Wilson, F.G.S., an accurate observer, on this point; and to the papers by this gentleman,[1] as well as to the memoir itself, the reader must be referred for further information. It is pointed out by Mr. Aveline that there is an unconformity in the north-eastern area between the Permian and the Trias, but that this is not greater than that which exists between the Middle Marls and the Lower Magnesian Limestone, or between the Bunter and the Keuper. It seems, therefore, that we may dismiss the notion of an "Upper Permian" series existing in this area.

(*b*) In South Lancashire, as has been recently shown by Mr.

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[1] *Vide* Quart. Journ. Geol. Soc. vol. xxxii.; also Mr. Wilson's paper in the *Midland Naturalist*, and letters to the Editor of the GEOL. MAG.

Strahan,[1] in a paper which he read at the last meeting of the British Association, a certain duplex series of marls and sandstones, which had been observed by Messrs. Hull and Binney cropping out in one place, and had been described by them as "Upper Permian," are really the base of the Triassic series in that district. In coal-pits recently sunk, and in "borings," they have been found lying conformably beneath the Triassic strata, and resting unconformably upon the Coal-measures. A comparison of the sections leads further to the inference that in the direction of their attenuation the lower series of these beds thins out faster than the upper, and in this way their general conformity with the Triassic beds above them is shown. The position, therefore, that these beds can justly be considered Upper Permian, is no longer tenable. This agrees with the information with which Mr. C. E. De Rance, F.G.S., has been kind enough to furnish me. He considers the "Upper Permian" of the Survey to be wanting in South and South-west Lancashire, and is doubtful if the Garstaig Sandstones ought to be so considered. Mr. De Rance also considers the so-called "Upper Permian" of North Lancashire to occupy the same horizon as the St. Bee's Sandstone (cf. *supra*).

*(To be continued in our next Number.)*

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## VI.—SUPPLEMENT TO A CHAPTER IN THE HISTORY OF METEORITES.

By WALTER FLIGHT, D.Sc., F.G.S.

*(Continued from p.* 111.)

### 1876, April 7th (evening).—Eperjes, Hungary.[2]

A fireball passed over Eperjes 8° [? E. or W.] from the meridian, and detonated at an altitude of 38° above the horizon. It exploded with a very loud noise, and broke into numerous fiery fragments.

### 1876, April 20th, 3·40 p.m.—Rowton, near Wellington, seven miles north of the Wrekin, Shropshire.[3]

It is not a little curious that twice in five years the British Islands have been visited with meteoric falls; in each case a single specimen has been found and, the one a small block of iron, the other a small block of rock, they constitute the prettiest little cabinet specimens of the two chief typical classes of meteorites. The former fell at Rowton, in April, 1876; the other near Middlesborough, in Yorkshire, on March 14th, 1881, and will be described later on. The Rowton iron weighs 7¾ lbs. A strange rumbling noise was heard in the air, followed almost instantaneously by a startling explosion resembling a discharge of heavy artillery. Rain was falling heavily at the time. About one hour after the explosion was heard a man had occasion to go into a turf field in his occupation adjoining the

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[1] *Vide* Reports of Section C. of the British Association for 1881.

[2] Egyetértés és Magyar Ujsag. Budapest, April 13, 1876.

[3] *Wolverhampton Chronicle*, and *Birmingham Daily Post*; *Nature*, April 7th, 1876, and *Nature*, July 27th, 1876. Walter Flight, Paper read before the Royal Society, February 9th, 1882.

Wellington and Market Drayton Railway, when his attention was attracted to a hole cut in the ground. He probed it with a stick and at a depth of eighteen inches, four inches being of soil and fourteen of solid clay, he found the mass of iron. The hole is nearly perpendicular, but the meteorite appears to have fallen in a S.E. direction. The mass was quite warm, it appears, when found.

The meteorite passed into the hands of Mr. Ashdown, the agent of the Duke of Cleveland, who presented it to the Trustees of the British Museum. The national collection contains 351 distinct meteorites, and of these 118 are iron masses, the fall of only seven of which has been witnessed; nine stony meteorites have fallen in the British Islands and the Rowton iron is only the second iron meteorite known as having been found in Great Britain. Mr. Maskelyne pointed out the resemblance to be traced between this iron and that of Nedagolla in India, both in its depth of penetration into the soil as well as the direction of the little mass in space.

The iron of this meteorite is compact and bright and the greater part of the surface is covered with a thin film of magnetite: the point where it struck the ground is worn bright. The composition of this iron was found to be:—

| | I. | II. |
|---|---|---|
| Iron | 91·250 | 91·046 |
| Nickel | 8·582 | 9·077 |
| Cobalt | 0·371 | |
| Copper | trace | trace |
| | 100·203 | 100·123 |

The fragment of iron chosen for analysis contained half a nodule of troilite, which was easily removed, and on analysis was found to have the composition:—

| | | Theory. |
|---|---|---|
| Iron | 63·927 | 63·64 |
| Sulphur | 36·073 | 36·36 |
| | 100·000 | 100·00 |

The occluded gases removed at a red heat with a Sprengel pump consisted of:—

| | |
|---|---|
| Carbonic acid | 5·155 |
| Hydrogen | 77·778 |
| Carbonic oxide | 7·345 |
| Nitrogen | 9·722 |
| | 100·000 |

The gases extracted were 6·38 times the bulk of the iron taken for experiment, an unusually large quantity; due doubtless to the iron being examined so soon after its fall.

### 1876, June 25th, 9—10 a.m.—Kansas City, Missouri.[1]

A small meteorite fell between nine and ten in the morning of the above day, on the tin roof of the house, No. 556, Main Street, Kansas City. It struck the roof with sufficient force to cut a hole in the metal; but it did not pass through, bounding back a few feet and coming to rest on the roof. Two observers who were at a window close by heard the sharp concussion when it struck the roof, and one of them immediately picked up the meteorite as it lay near her on the roof, but let it fall again, finding it too hot to retain in the hand. It is described as of a plano-convex form, one inch and three quarters along its greatest length and about one third of an inch thick. "The convex surface possesses the usual crusted appearance, while the inside or plane surface differs from ordinary meteorites in possessing the appearance of sulphuret of iron, subjected to some degree of heat, instead of nickeliferous iron. One might easily infer that the meteorite was shaled off from a large bolide that passed over the city at that time." It is much to be desired that this meteorite will pass into the hands of a scientific expert for examination and description.

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[1] J. D. Parker, *Amer. Journ. Sc.* 1876, vol. xii. p. 316.

Prof. Kirkwood describes eight large fireballs, between July, 1876, and February, 1877 (*American Journal of Science*, 1877, vol. xiv. p. 75); the time and the real path and appearance of one was:—

1876, July 8th, 8.45 P.M.—From an altitude of 88 miles, passed N. 78° W. across the N.E. of Indiana and exploded over Lake Michigan at an altitude of 34 miles. The path was inclined 21° to the horizon; no detonation reported; train visible 40 minutes.

### 1876, June 28th, 11·50 a.m.—Ställdalen, near Kopparberg, Örebrolän, Dalecarlia, Sweden.[1]

A meteor traversed a part of Central Sweden in a W.N.W. direction, and was plainly visible in the very bright sunshine. It was observed at Stockholm and Södermanland; at 13 English miles S.W. of Linköping it was seen first in a N.W. direction, and at a considerable altitude, and it descended almost to the horizon in the west. A loud whistling noise was heard in the air from E. to W., followed by two sharp reports, and others less loud resembling thunder. The fall of the meteorites was witnessed by eight or ten persons, and three or four fragments have been secured by Dr. Lindström. The largest, about the size of two fists, weighs 4½ skalpund [1 lb. av.=1·068 ltt. or skalpund]. Ställdalen is a station on the Swedish Central Railway, on the northernmost part of Örebrolän. Some of the meteorites which fell in water have been lost.

It was subsequently ascertained that the total number of stones found is eleven, and they weigh collectively 34 kilog. Lindström finds the total composition of a portion of one of these stones to be—

| | |
|---|---|
| Silicic acid | 35·71 |
| Phosphoric acid | 0·30 |
| Alumina | 2·11 |
| Chromium oxide | 0·40 |

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[1] A. E. Nordenskjöld, Föredrag i Mineralogi vid Akademiens ärshögtid den 3 April, 1877. ('Aftonbladets Aktiebolags Tryckeri,' Stockholm, 1877.) [See also *Nature*, July 19th, 1877.]—G. Lindström, 'Öfversigt af Kongl. Vetenskaps *Akad. Förhandl.*,' No. 4, 1877, p. 35.

| | |
|---|---|
| Iron protoxide | 10·29 |
| Manganese protoxide | 0·25 |
| Nickel protoxide | 0·20 |
| Lime | 1·61 |
| Magnesia | 23·16 |
| Soda | 0·62 |
| Potash | 0·15 |
| Iron | 21·10 |
| Nickel | 1·61 |
| Cobalt | 0·17 |
| Phosphorus | 0·01 |
| Sulphur | 2·27 |
| Chlorine | 0·04 |
| | 100·00 |

Of these ingredients, 4·51 per cent. constitute magnetic pyrites, and 14·65 per cent. nickel-iron, the composition of which appears to be—

| | |
|---|---|
| Iron | 90·78 |
| Nickel | 8·29 |
| Cobalt | 0·88 |
| Phosphorus | 0·05 |
| | 100·00 |

The portions (I.) gelatinisable with and (II.) unacted upon by acid have the following composition:—

| | I. | II. |
|---|---|---|
| Silicic acid | 36·76 | 57·37 |
| Phosphoric acid | 0·83 | 0·07 |
| Alumina | 0·13 | 5·07 |
| Iron protoxide | 20·35 | 8·03 |
| Nickel oxide | 0·60 | — |
| Manganese oxide | — | 0·63 |
| Lime | 0·64 | 3·41 |
| Magnesia | 40·47 | 23·54 |
| Soda | 0·18 | 1·38 |
| Potash | 0·16 | 0·23 |
| Chlorine | 0·13 | — |
| | 100·25 | 99·73 |

In the soluble portion the oxygen ratio of acids to bases is 20·08 : 21·16, and in the insoluble part 30·64 : 15·08. In addition to olivine and bronzite, this meteorite appears to contain an insoluble felspar and a little apatite.

### The Meteoric Irons of the Mexican Desert.[1]

Dr. Lawrence Smith takes stock afresh of our knowledge of the masses of meteoric iron of that region of Mexico called the *Bolson de Mapini*, or the Mexican Desert, situated in Cohahuila and Chihuahua, two of the northern provinces of the Mexican Republic. In 1854 he described three masses, two of which (one weighing 630 kilogrammes, and the other 125 kilog.) were subsequently conveyed to the United States; in 1868 eight other masses, the largest of which weighed 325 kilog., were conveyed to the United States; and later still, in 1871, Dr. Smith published a description of a still larger block, estimated to weigh 3,500 kilog., now lying in the western

[1] J. L. Smith, *Amer. Journ. Sc.* 1876, xii. 107.

boundary of the Desert near El Para. There is, moreover, some account of a mass yet vaster to be seen in the very centre of the desolate region. In this district alone not less than 15,000 kilogrammes in weight of meteoritic masses have been discovered.

While examining sections of two of the above-mentioned masses, Dr. Smith noticed a number of nodular concretions imbedded in the metal, having at first sight the appearance of "very finely crystallized troilite"; closer inspection, however, reveals the fact that most of these nodules have more or less of a black mineral associated with them. This substance was ascertained to be—not graphite, as might at first sight have been supposed,—but *chromium monosulphide*, a mineral new both to terrestrial and celestial mineralogy.

Daubréelite, as Dr. Smith has named it, is a black lustrous mineral, highly crystalline, usually occurring on the surface of the nodules of troilite, but sometimes traversing them; in one nodule a vein of the mineral, 2 millims. wide and 12 millims. in length, crosses the very centre of a nodule. It exhibits a distinct cleavage, is very fragile, and is feebly magnetic: the powdered mineral is perfectly black, and is but slightly acted upon by strong acids, with the exception of nitric acid, in which it completely dissolves; this reaction serves to distinguish and separate it from chromite. The mineral has not yet been completely analyzed; one hundred milligrammes were examined and found to contain 36·48 per cent. of sulphur, the remainder being chromium, with nearly 10 per cent. of iron, and a little carbonaceous matter. (Chromium monosulphide contains chromium = 62·38, and sulphur = 37·62; iron-monosulphide troilite contains iron = 63·64, and sulphur = 36·36.) The discovery of this new body is of great interest in extending the knowledge already arrived at by aid of the spectroscope of the distribution of chromium in cosmical bodies.

Dr. L. Smith[1] publishes a further paper on the new mineral occurring in the irons, to which mineral he has given the name of daubréelite. It possesses the following composition:—

| | Calculated. | Found. |
|---|---|---|
| Sulphur | 44·29 | 43·26 |
| Chromium | 36·33 | 36·38 |
| Iron | 19·38 | 20·36 |
| | 100·00 | 100·00 |

It is a sulphide corresponding in atomic constituents to the well-known oxide, chromite ($FeO,CrO_3$), daubréelite being $FeS,CrS_3$, sulphur replacing the oxygen. The calculation of the composition is based upon the sulphur found in the analyses. The finer powder obtained by cutting sections of the irons are treated with a magnet to remove the nickel-iron; that remaining consists of troilite and daubréelite. This is then digested with strong hydrochloric acid several times; all the troilite dissolves readily, and the residue consists of the new sulphide. "It consists of shining black fragments, more or less scaly in structure, not altogether unlike fine particles of molybdenite." The fracture is uneven, except in one direction, where there appears to be a cleavage. It is brittle and easily pulverized, the fine particles retaining their brilliancy. It is not magnetic, and but slightly altered before the blow-pipe. It is not acted upon in the slightest degree by hydrochloric acid, either cold or hot, but dissolves slowly and completely in nitric acid when warmed with it. The specific gravity is 5·01.

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[1] *Amer. Journ. Sc.* 1878, xvi. p. 270.

Other meteoric irons, such as those from Toluca, Mexico, and Sevier Co., Tennessee, contain this mineral.

Some time ago attention was directed to the discovery by Dr. L. Smith[1] of daubréelite in one of these irons. He has since met with a nodule of chromite in the interior of compact iron from one of these masses. His attention was attracted to an inclosed nodule, the lustre of which was less vitreous than that of the chromium sulphide: it was virtually a black granular mass. When heated with strong nitric acid in the water-bath, not the slightest impression was made upon it, thus showing that it is not daubréelite. Heating it in fused sodium carbonate in no way affected its non-solubility in acids; 150 millegrammes of the finely pulverized mineral were fused with ten times its weight of sodium bisulphate and were attacked but not dissolved. Subsequent treatment with sodium carbonate and nitre broke it up and the results of the analysis were:

| | |
|---|---|
| Chromium oxide ... ... ... ... ... ... ... ... | 62·71 |
| Iron protoxide ... ... ... ... ... ... ... ... | 33·83 |
| | 96·54 |

While chromite has been known to be associated with meteorites, this is the first instance of its having been found imbedded in this manner in the interior of meteoric iron.

Some of the particles of chromite when placed in very intense light were found to be feebly translucent and to have a dark reddish-purple colour. This observation, it appears, had already been made by M. Stanislaus Meunier, of Paris.

### 1876, December 21st, 8·40 p.m.—Rochester, Fulton Co., Indiana. [Lat. 41° 8′, Long. 86° 12′][2]

This remarkable meteor passed over the States of Kansas, Missouri, Illinois, Indiana, and Ohio, a distance from E. to W. of about 800 miles. It burst into numerous fragments during its passage, producing "a flock of brilliant balls chasing each other across the sky, the number being variously estimated from twenty to one hundred." Over all the regions of Central Illinois a series of terrific explosions was heard. Over the northern part of Indiana the passage of the body was followed by loud explosions. A piece of the meteorite, a few ounces in weight, fell near Rochester, Ia. A portion in the possession of Prof. Shepard was discovered on the following day lying in the snow. Two places were noticed where it had previously struck, whence it had bounded to its resting-place.

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[1] *Amer. Journ. Sc.* ii. 1871, and xvi. 1878, 270.

[2] H. A. Newton, *Amer. Journ. Sc.* 1877, xiii. 166; J. L. Smith, *Amer. Journ. Sc.* 1877, xiii. 243, and xiv. 219; C. U. Shepard, *Amer. Journ. Sc.* 1877, xiii. 207; Prof. Kirkwood, *Amer. Journ. Sc. 1877,* xiv. 75.

It is stated by Prof. Shepard to closely resemble the meteorite of Pegu, India (27th December, 1857), and to consist of dark ash-grey spherules (Boltonite), imbedded in a nearly white pulverulent matrix, "chladnite," olivine in distinct grains, nickel-iron, and a little troilite. The specific gravity of a fragment partially covered with crust was 3·65.

According to Prof. Kirkwood its elevation at Bloomington, where it was well noticed, was fifteen degrees, and it is calculated that the length of the observed track was from 1000 to 1100 miles, one of the longest on record. Its height is supposed to have been thirty-eight miles above the place where the small fragment fell from it. Its velocity in reference to the earth's surface appears to be from eight to twelve miles per second. The pyrotechnical display is said to have been transcendently beautiful.

The entire fragment did not weigh 400 grammes, and it is reasonable to suppose that the stone itself was dissipated into very minute fragments and dust, as appears to have been the case in the Hessle fall and in other similar instances. The stone, according to Dr. L. Smith, is markedly pisolitic (highly chondritic), very friable, of a grey colour, is easily crushed between the fingers into a light powder, some to a fine dust, and to small globules, some of them being perfectly spherical. In many respects it appears to bear a close resemblance with the Ornans meteorite. Dr. L. Smith found it to resemble most closely the Aussun stone. The coating is dull black and quite rough, and the specific gravity 3·55. The stone contained 3·31 per cent. of troilite, and on treatment with hydrochloric acid was found to consist of:—

| | |
|---|---|
| A. Soluble silicates | 47·80 |
| B. Insoluble silicates | 52·20 |
| | 100·00 |

which contained respectively:—

| | A. | B. |
|---|---|---|
| Silicic acid | 34·55 | 57·81 |
| Iron protoxide | 27·75 | 11·04 |
| Alumina | trace | 0·23 |
| Chromium oxide | —— | 0·10 |
| Lime | trace | 5·31 |
| Magnesia | 36·38 | 24·97 |
| Soda | 0·46 | 0·84 |
| | 99·14 | 100·30 |

Some of the globules, when picked out and analyzed, were found to possess the same composition as that of the complete rock itself, which showed them to be merely concretions of the matrix. The nickel-iron contained:—

Iron = 94·49; Nickel = 4·12; and Cobalt = 0·51; = 99·12.

The mineral constituents of the Rochester meteorite are:—

| | |
|---|---|
| Bronzite and pyroxene minerals | 46·00 |
| Olivine | 41·00 |
| Nickel-iron | 10·00 |
| Troilite | 3·00 |
| Chrome iron | 0·15 |

(*To be continued in our next Number.*)

# VII.—THE LIFE AND WORK OF LINNARSSON.

By Prof. CHAS. LAPWORTH, F.G.S.

(*Concluded from page* 122.)

WE now enter upon the third and concluding term of Linnarsson's geological career. This extended from the commencement of the year 1876 to the date of his untimely death in September, 1881. Hitherto, he had been occupied mainly in the development of the grander natural divisions of the Lower Palæozoic Succession of Sweden. This final period was devoted to the task of elaborating their minor subdivisions and best-characterized zones of life.

In a paper contributed to the GEOLOGICAL MAGAZINE in June, 1876, on the "Vertical Range of the Chief Graptolitic Types in Sweden," Linnarsson unconsciously struck into the new path of original research and discovery he followed thenceforward to the end of his life. On reading the MS. of this paper and examining the illustrative examples forwarded by him to my friend Professor H. Alleyne Nicholson, I was greatly pleased to find that the range of the Swedish forms noticed corresponded precisely with the range of the same species in British rocks as previously worked out by myself. This circumstance prompted me to lay before Linnarsson the chief points I had already developed respecting the true order of the Graptolite-bearing strata of Britain, and the vertical range of some of the more characteristic species occurring within them. He was delighted to find that his deductions were in harmony with my own, and in return gave me a detailed account of all that had been accomplished in this department in Sweden up to that date. He followed with the keenest interest every stage of my later work among the Palæozoic rocks and fossils of Britain, applied the same methods of research to the Graptolite-bearing rocks of Sweden, and long before his death had placed it absolutely beyond question that the grander Graptolitic zones recognizable among the Lower Palæozoic rocks of this country have their exact parallels in Sweden, and are characterized either by the same, or by a representative series of these fossils. The study of the *subordinate* zones and their characteristic Graptolithina has been taken up with great earnestness of late years by Linnarsson's pupil and successor, Dr. Sven Tullberg, whose published works upon this subject are a sufficient proof that this task will be completed in a manner worthy of the master himself.

A memoir upon the Graptolitic shales of Kongslena in Westrogothia (1877) was Linnarsson's earliest contribution to this special subject. In this paper he made known the existence of a typical Birkhill Graptolite fauna in the lower division of the Upper Graptolite Shales of Sweden, and showed, what had already been insisted upon by myself as regards Britain, that this fauna was of more recent date than the Llandeilo, to which it had hitherto been referred, and was in all likelihood of Llandovery age.

Linnarsson's succeeding memoir, "Upon the Graptolite-bearing Shales of Scania," has been already noticed in detail in the pages of this MAGAZINE (Vol. VII. 1880, pp. 29 and 68). It is a paper of which it is impossible to speak too highly. It marks a new departure in the history of Swedish geology,—the extension of the method of "zones" to the investigation of the sequence among the lithologically similar masses of Graptolitic Shales,—a method which is at present being extended with minute elaboration and most remarkable results to the development of the succession among the entire series of Graptolitic Shales in Sweden, by Dr. Tullberg in Scania, and by Dr. Sven. Törnquist in the more complicated region of Dalarne.

Additional Graptolite-bearing strata, of Cambrian age, were detected by Linnarsson in 1870, in the district of Westrogothia, in the upper part of the Swedish representative of the British Tremadoc formation; and corresponding beds with *Dictyonema* in the same region in 1880. His last published paper (1880) contains an account of his discovery of typical Gala Beds (beds with *Monograptus turriculatus*, Barr.), in the neighbourhood of Motala, Central Sweden.

Hitherto we have confined our remarks to the *geological* labours of Linnarsson, as it is upon these that his well-earned fame will mainly rest in the future. His strictly *palæontological* works, however, demand a special notice in this place; for in interest and importance they are nowise inferior to his geological studies; while in clearness of description, and in the evidences they afford of keenness of palæontological insight, and conscientious accuracy of description, they are worthy to be compared with the best efforts of Angelin himself.

Linnarsson's earlier palæontological labours were confined almost wholly to the *Trilobita*. In this department of the science he enjoyed exceptional advantages in being able to study the magnificent type collection of Angelin. His first ambitious attempt in this direction—the supplement to his own "Vestrogötlands Cambriska och Siluriska Aflagringar," is perhaps his masterpiece, and is demonstrative of the profundity and accuracy of his knowledge of the group. Let the reader compare the minute descriptions of the new or little known forms in this work, and their careful allocation to their definite horizons in the vertical series, with the curt descriptions and rough localization of the older species as given in Angelin's "Palæontologica Scandinavica," and the contrast between the broad half-careless glance of the master, and the searching and microscopically accurate gaze of his great pupil is at once apparent. Linnarsson's knowledge of the Trilobita was the thorough knowledge of a specialist, descending to minutiæ far beyond the reach of the general palæontologist.

The several papers published by Linnarsson upon the Trilobita of Sweden are, as will be seen from the list appended to the present memoir, some seven or eight in number. Three of these are of especial interest. In 1871 he described a new form of *Paradoxides* (*P. Kjerulfi*) from the "Primordial Zone" of Sweden and Norway. This form, which belongs to the same type as the *Olenellus* of Billings, is to-day remarkable as being the oldest Trilobite form yet detected in Scandinavia, forming the type species of the lowest Trilobite zone throughout the peninsula and the neighbouring islands. In 1877 he gave a careful analysis and description of the forms composing the fauna of a second horizon in the "Primordial Zone" of Öland, characterized by the strange form *Paradoxides Ölandicus* (Sjögren). This horizon, placed by Sjögren in the higher part of the Paradoxidian, is at present, through the researches of Dr. Nathorst and Prof. Brögger, of Christiania, known to be actually situated immediately above the zone of *P. Kjerulfi*, as suggested by Linnarsson himself many years ago, in opposition to the physical testimony apparent at the time. Linnarsson's elaborate paper upon "The fauna of Conocoryphe Exsulans Limestone" has been already referred to at length in these columns. His last paper upon Trilobites is entitled "On the species of fossils in the Swedish bed with *Peltura scarabeoides.*" It was published in 1880, and gives a most exhaustive description of the Swedish fauna of this special zone of the Upper Cambrian, which answers to the Dolgelly Group of Belt, and the well-known Olenus-bearing black shales of Malvern; at least six out of the nine forms noticed by Linnarsson being common to the British and Scandinavian strata of the zone.

The chief fruit of Linnarsson's studies of the Brachiopoda was his well-known paper on the "Brachiopoda of the Paradoxides Beds of Sweden," written in English and published in the year 1876. In this memoir he gave a minute description of the eleven forms occurring in the Swedish deposits of this age (many of them being new species), illustrated with excellent figures, and tables showing the sequence and fossils of their containing beds.

Of late years Linnarsson, as we have already pointed out, devoted special attention to the Graptolithina, which interested him greatly because of their value as geological indices of the position of their containing zones. He published, however, only two palæontological memoirs upon the group. The first (on the Graptolites of Gothland) I have already noticed (Geol. Mag. 1880, p. 68). The second (on the Graptolites of the Zone of *M. turriculatus* near Motala) was published just before his death. It is altogether an excellent memoir upon this new subject; and it shows how earnestly and thoroughly Linnarsson performed his palæontological work, and with what patience and care he must have devoted himself to the study of these formerly neglected fossils.

The winter before his death Linnarsson completed the geological mapping of the sheet "Vreta Kloste," and wrote a description for the press. In addition he prepared a monograph upon the "Lower Paradoxides Beds of Andrarum," giving an account of the stratigraphy of the component beds and an extended description of the included fossils, of which some 44 are new to science. It is satisfactory to learn that this work is now being printed, and will soon appear among the scientific memoirs issued by the Swedish Geological Survey.

At the time of his death, Linnarsson was busied on collecting materials for a monograph of the Lower Palæozoic strata of Ostrogothia, a region to which he had devoted much attention during the last few years.

It is, perhaps, no surprise to many of us to learn that Linnarsson's dearest project was the publication of a comprehensive work—*Siluria Suæcica*, upon the Lower Palæozoic rocks and fossils of his native land. This idea seems long to have possessed him, and for many years past his plan of labour, and his method of accumulation of material and publication of results, were all arranged to this special end. Indeed, he appears to have left behind him a large portion of this work in manuscript. It is to be hoped that this relic is in a sufficiently complete state to admit of its publication, and that some one of his learned colleagues upon the Survey will generously edit it. It is but fitting that everything which Linnarsson wrote should be devoted to the advancement of the science for which he lived, and for which he died. Linnarsson's fame rests securely upon the extent, the brilliance, and the perfect reliability of the work he accomplished, and the main results of which he published, during his lifetime. But with the magnificent example of the posthumous memoirs of Angelin before our eyes, we cannot but feel that the name of Linnarsson is worthy as splendid a monument.

Linnarsson was a good classical scholar, and took an especial delight in the beauties of Grecian literature. Personally, he was frank and generous, gaining the life-long esteem and affection of all with whom he became associated, equal and inferior alike. Hopeful, honest, modest, and unselfish, his sunshiny nature rendered him an eminently lovable companion and friend, while at the same time he was an unsparing enemy of all that was mean and self-seeking.

Linnarsson's contributions to the Geology of Sweden will be apparent upon a study of the following table, which gives the succession of the Swedish formations as developed by him in the papers published previous to his death (1881).

### TABLE SHOWING THE NATURAL SUCCESSION AMONG THE LOWER PALÆOZOIC STRATA OF SWEDEN, AS DEVELOPED BY THE LABOURS OF DR. G. LINNARSSON.

(September, 1881.)

*A*. CAMBRIAN SYSTEM.

I. *Eophyton Sandstone* (Linnrs.).
II. *Fucoid Sandstone* (Linnrs.).
III. *Paradoxides Beds* (Linnrs.).
1. Strata with *Paradoxides Kjerulfi* (Linnrs.).
2. ,, (*Paradoxides ölandicus*) (Linnrs.).
3. ,, *Paradox. Tessini*, Brongn. (Linnrs.).
(*a*). *Exsulans Limestones* (Linnrs.).
(*b*). *Subzone* with *P. Hicksii*, Salt. (Linnrs.).
(*c*). ,, *Agnostus rex*, Barr. (Linnrs.).
4. Strata with *Paradoxides Davidis*, Salt. (Linnrs.).
5. ,, ,, *Forchhammeri*, Salt. (Linnrs.)
6. ,, *Agnostus lævigatus*, Dalm. (Linnrs.).
IV. *Olenus Shales* (Linnrs.).
1. Beds with *Agnostus pisiformis*, Linnrs.
2. ,, *Beyrichia Angelini*, Barr.
3. ,, *Orthis lenticularis*, Wahl.
4. ,, *Leptoplastus* and *Eurycare*.
5. ,, *Peltura scarabeoides*, Wahl.

V. ***Dictyonema Shales*** (Linnrs.).
  1. Strata with *Dictyonema flabelliforme*, Eichw.
  2. ,, *Obolella Salteri*, Holl.

*B.* ORDOVICIAN SYSTEM.

I. *Ceratopyge Limestone* (Linnrs.).
II. Lower Graptolite Shales (Linnrs.) (Phyllograptus Shales of Dr. Tornquist).
III. Orthoceras Limestone.
IV. Middle Graptolite Shales (Linnrs.).
  1. Zone with *Phyllograptus typus*, Hall.
  2. ,, *Didymograptus geminus*, His.
  3. ,, *Glossograptus Hicksii*, Hopk.
  4. ,, *Diplogr. mucronatus*, Hall (?).
  5. ,, *Clima. Scharenbergii*, Lapw.
  6. ,, *Dicranograptus Clingani*, Carr.
  7. ,, *Orthis argentea.*
V. *Chasmops Limestone* (Linnrs.).
VI. *Trinucleus Shales* (Linnrs.).

*C.* SILURIAN SYSTEM.

I. *Brachiopod Shales* (Linnrs.) in part only.
II. *Upper Graptolite Shales* (Linnrs.).
  1. Lobiferus Shales (of Tornquist).
    ,, Strata with *M. turriculatus*, Barr. (Linnrs.).
  2. Retiolites Shales (of Tornquist).
  3. Shales with *Monograptus testis*, Barr. (Linnrs.).
  4. ,, ,, *colonus*, Barr. (Linnrs.).
III. *Klinte Sandstones* of Scania.

### LIST OF LINNARSSON'S SCIENTIFIC MEMOIRS.

1. 1866. On the Silurian Formations in Westrogothia. Upsala, 8vo. pp. 25, 2 plates.
2. 1868. Contribution to the Geology of Westrogothia. Öfversight K. Vet. Akad. Förh. Årg. 25, pp. 53—61.
3. 1869. Diagnoses of New species of Crustacea from the Cambrian and Silurian Deposits of Westrogothia. *Ibid.* Årg. 26, pp. 181—196.
4. ,, On the Cambrian and Silurian Succession in Westrogothia. K. Vet. Akad. Handlingar, Bd. 8, No. 2, pp. 89, 2 plates.
5. ,, On some New Fossils from the Sandstone Beds of Westrogothia.[1] Öfvers. K. Vet. Akad. Förh. Årg. 26, pp. 337—357, plates vii.—ix.
6. 1870. Geognostical and Palæontological Observations on the Eophyton Sandstone in Westrogothia. K. Vet. Akad. Hand., Bd. 9, No. 7, pp. 19, 5 plates.
7. 1871. Comparison of the Silurian Succession in Dalarne and Westrogothia. Öfversigt K. Vet. Akad. Förh. Årg. 28, sid. 339—354.
8. ,, On some New Fossils from the Primordial Zone of Sweden and Norway. *Ibid.* Årg. 28, sid. 789—796, Taf. xvi.
9. 1872. Notes on the Cambro-Silurian Succession in Jemtland. Geol. Fören. Förh. Bd. 1, sid. 34—37.
10. 1873. Report of a Scientific Tour to Bohemia and the Baltic Provinces of Russia. Öfvers. K. Vet. Akad. Förh. Årg. 30, sid. 89—111.[2]
11. ,, A Comparison of the Cambro-Silurian Succession in Sweden, Bohemia, and the Russian Baltic Provinces. Förh. Skard. Naturforsk, Copenhagen, 1873, sid. 269—272.
12. ,, Trilobites from the Andrarum Limestone of Westrogothia. Geol. Fören. Förh. Bd. 1, sid. 242—248.

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[1] Compare GEOLOGICAL MAGAZINE, Vol. VI. pp. 393—406. Pl. XI.-XIII.

[2] Compare Zeitschrift d. Deutsch. Gesellschaft, 1873, p. 675.

13. 1874. Fossils from Lapland, collected by Herrn Sidenbladh and E. Erckmann. Geol. Fören. Förh. Bd. ii. sid. 129—131.
14. 1875. Description of the Sheet "Latorp." Swedish Geological Survey Publications: Ser. A. No. 55, pp. 42; together with a Geological Map on a scale of 1—50,000.
15. ,, Notes of a Journey on the Silurian Tracts of Scania in 1874. Geol. Fören. Förh. Bd. ii. sid. 260—284.
16. ,, On a Remarkable Trilobite Fauna from Jemtland. *Ibid.* pp. 491—497, Taf. xxii.
17. ,, On Two New Trilobites from the Alum Shales of Scania. *Ibid.* sid. 498—501.
18. ,, Outline of the Transition Formations of Nerike. Öfvers. K. Vet. Akad. Förh. Årg. 32, No. 5, sid. 3—47, Taf. iv. and v.
19. ,, On the Brachiopoda of the Paradoxides Beds of Sweden. Bihang till K. V. Bd. Handl. Bd. iii. No. 12, pp. 34, 4 plates.
20. 1876. Geological Observations during a Journey in Öland. Geol. Fören. Förh. Bd. 3, sid. 71—86.
21. ,, A Comparison between the Oldest Fossiliferous Rocks of Northern Europe. Geol. Mag. Dec. II. Vol. III. pp. 145—150, and 287—288.
22. ,, On the Vertical Range of the Graptolitic Types in Sweden. *Ibid.* pp. 241—245. Compare also pp. 525—526.
23. 1877. Discovery of Andrarum Limestone at Hunneberg in Westrogothia. Geol. Fören. Förh. Bd. iii. sid. 346—347.
24. ,, On the Fauna in the Beds with *Paradoxides Ölandicus.* *Ibid.* 352—375, Taf. 14 and 15.
25. ,, On the Graptolite Shales of Kongslena in Westrogothia. *Ibid.* pp. 402—410. Compare Geol. Mag. 1878, pp. 278—281.
26. 1878. The Palæozoic Formations of Humlenas in Småland. Geol. Fören. Förh. Bd. iv. sid. 177—184, Taf. 12.[1]
27. 1879. Observations upon the Graptolite-bearing Shales in Scania. Geol. Fören. Förh. Bd. iv. sid. 227—238 and 241—257.
28. ,, Ceratopyge Limestone and Lower Graptolite Shales at Falbygden in Westrogothia. *Ibid.* sid. 269—270.
29. ,, "Jordskalfvet" in Central Sweden, 2nd February, 1879. *Ibid.* sid. 295—331, Taf. 19.
30. ,, On the Graptolites of Gothland. Öfvers. K. Vet. Akad. Förh. Årg. 36, No. 5, sid. 3—11, Taf. x.
31. ,, On the Fauna of the Limestone with *Conocoryphe Exsulans.* Sveriges Geol. Survey, Ser. C., No. 34, pp. 31, Taf. i.—iii.
32. 1880. On the Oldest Palæozoic Strata in the Tract around Motala. Geol. Fören. Förh. Bd. v., sid. 23—30, Taf. i.
33. ,, On the Geological Succession in the District around Hjo. *Ibid.* sid. 102—109.
34. ,, Dictyonema Shales at Orreholmen in Westrogothia. *Ibid.* sid. 108—109.
35. ,, On the Fossils in the Swedish Beds with *Peltura* and *Spherophthalmus.* *Ibid.* sid. 132—161, Taf. 5 and 6.
36. 1881. Graptolite Shales with *Monograptus turriculatus* at Klubbuden near Motala. *Ibid.* sid. 503—526, Taf. 22 and 23.
37. ,, The Lower Paradoxides Strata of Andrarum. Publications Swedish Geol. Survey, Series C. (not yet issued).

[1] Compare also Geol. Mag. 1878, pp. 93 and 96, and pp. 188 and 189.

Note.—For many of the facts bearing upon Linnarsson's private life, and his early scientific career, I am indebted to the kindness of his intimate friend and companion, Dr. A. G. Nathorst, of Stockholm. A most appreciative and exhaustive account of "Linnarsson's Contributions to the Geology and Palæontology of Sweden," by this author, will be found in the Geol. Förh. Stockholm, for December, 1881.

## VIII.—SUGGESTED ANALOGY BETWEEN "WATER HAMMER" ACTION AND EARTHQUAKE AND VOLCANIC PHENOMENA.

By THOMAS MUDD.

PROF. PRESTWICH, in his paper in the January Number of this MAGAZINE on the "Causes of Volcanic Action," assumes the existence of hot reservoirs or cavities filled with molten rock, and cold reservoirs or cavities, nearer the surface, filled with water; and he supposes the shrinkage of the Earth to squeeze up the molten rock till it meets with the water, which then explodes, producing a volcano.

I would suggest that the action which goes on in the fissures that connect the hot and cold cavities is similar to the "water hammer" action, so well known to engineers. This assumption is necessary, it seems to me, to render the theory completely satisfactory.

Water hammer action manifests itself where steam has to be conveyed to considerable distances from its source without any return communication or easy vent. It occurs in this way. The steam, on being turned into the cold pipes, is quickly condensed, and in a short time a quantity of water is formed. The steam condensing most quickly at the end furthest from the inlet, there is there formed a partial vacuum. The steam rushing forward in consequence, gathers up the water into a plug, which fills the sectional area of the pipe, and forms indeed a water piston. This water piston is dashed by the force of the steam against the end of the pipe, producing a severe shock, accompanied by a loud report; and then follows by natural sequence a rebound, which must be a rebound of a compound character, made up in part of the rebound of the steam, in part of the rebound of the water, and in part of the effort of the water to regain its level by gravity. The first two are probably of momentary existence, but the last takes time, and proceeds with a measured swing like a mighty pendulum. When the force of the return wave is spent, and the steam again gets the advantage, condensation having in the mean time been going on behind the return wave, this piston of water advances a second time, and is dashed with increased fury against the obstruction in the pipe. This action in a few strokes arrives at its maximum, and thence, if the pipe has been able to withstand the shocks, gradually diminishes and dies away.

There are two operations at work affecting its destiny. The quantity of water set in motion is increasing, tending to increase the shock, and the temperature of the pipe is heightening, tending to diminish the shock by reducing the difference of pressure between the spaces before and behind the water plug. The latter is by far the more potent agent, and quickly reduces the water hammer action to nothing.

Now the essentials to this kind of action are—1. A length of passage confined at its extremity. 2. A fluid. 3. A condensible vapour. 4. A difference of temperature at the two extremities of the passage. 5. The initial action, which is merely the introduction of the condensible vapour into the colder end of the passage from the hotter, so that it may be under conditions producing condensation, and thus commence the water hammer action.

That this kind of action, owing largely to the very low compressibility of water, is capable of producing very severe shocks, even when the essential factors are of comparatively low value, is seen from the fact that stout iron pipes of only a few inches in diameter are often burst into fragments by it, even when the difference of pressure developed cannot be more than about 50 lbs. per square inch, and where the length of pipe is not many yards.

Given, therefore, subterranean reservoirs, as Prof. Prestwich supposes, we have only to assume a communication formed between these two reservoirs by a fissure, and we shall have the conditions favourable for the water hammer action on such a gigantic scale as appears competent to account for the phenomena of earthquakes and volcanoes. Immediately a fissure is formed connecting the reservoirs of water nearer the surface and at comparatively low temperature with the more deep-seated reservoirs of molten rock, steam is formed, which, passing along the fissure, becomes condensed, difference of pressure is set up, the water and molten rock form a fluid piston or plug, and shocks proportionate to the difference of pressure, the length and sectional area of the passage, and to the quantity of matter set in motion, are thence inevitable.

If, when this action arrives at its maximum, the water cavity is incapable of sustaining the shock, and gives way, its broken walls are thrown out as dust and ash, the whole body of the water, which had become superheated, bursts into steam, and the molten rock is poured out as lava.

There is another analogy indirectly connected with this matter, which appears to hold between the conditions beneath the crust of the earth and those in a steam boiler, to which I shall only make a brief reference, as the question has been dealt with in well-known geological works. It bears upon the observed fact that mountain ranges occur mainly along lines of thick deposit. If a sediment (especially one of a loose or of a greasy character) be allowed to accumulate on the outside of the fire-tube of a boiler, the heat is prevented from getting through the iron plate sufficiently fast to prevent overheating. The contact of the plate with the water is broken, and the sediment is a bad conductor. The result is that the plate becomes overheated, and the external pressure on the fire-tube thrusts it out of shape, producing what is known as a "collapsed furnace."

This seems to illustrate what takes place on a large scale in areas of great deposition. The thick loose sediment forms a bad conductor, overheating takes place, and that first, of course, along the line of thickest deposit, and the pressure being internal instead of external, a ridge outside is the result instead of a collapse.

## REVIEWS.

### GEOLOGY OF THE COUNTIES OF ENGLAND AND OF NORTH AND SOUTH WALES. By W. JEROME HARRISON, F.G.S., etc. Pp. 346. (London, 1882: Kelly & Co.) Price 8s.

DURING the past six years Mr. Harrison has contributed excellent geological sketches of most of the English counties to the local Post Office Directories, published by Messrs. Kelly and Co. In these sketches he gives an account of each formation, its fossils and the economic uses of the rocks, together with notes on the scenery of the country, and on other matters of geological interest. They have now been reprinted with geological descriptions of those counties not previously published, and with the addition of references to the Natural History and Scientific Societies of each county, the Museums, the publications of the Geological Survey, and the important works or papers on Local Geology. The author has evidently bestowed great labour upon his work, and although the sketches do not do equal justice to every county, the information has been carefully selected from original sources. Hence, with the bibliographical references, the work will be a most useful guide to all who are desirous of learning what they can of the stony structure and ancient history of the English counties. If we find fault at all, it is that the more important papers of the earlier geologists are seldom mentioned in the lists, as, for instance, those of Sedgwick on Cumberland and Westmoreland; those of Sedgwick and Murchison and of Godwin-Austen on Devonshire; of Buckland and Conybeare on Somersetshire; while we miss the name of Prestwich in the Shropshire list, and that of Binney in the Lancashire list. Fitton's great work on the Beds between the Chalk and the Purbeck Limestone should have been mentioned in the list on page xxvii; the only other reference we have found to this work being on p. 217 in the list of works on the Geology of Rutland. Most of the older geologists, however, are mentioned by name, and it is only because undue prominence appears to be given to later writers that we have remarked on the subject; for Mr. Harrison has always made most generous acknowledgment of the sources of information to which he has been indebted.

The work contains 106 illustrations, comprising pictorial views, sections, fossils, and flint implements. The sections are mostly borrowed from the Geological Survey publications, as stated in the preface. Particular references to the works from which they are taken is an omission that may be supplied in a future edition of the work.

Hitherto, no attempt has been made to combine in one volume separate accounts of the geology of our counties, although a geological atlas of the country was published about twenty years ago by Reynolds. This, if brought up to date, would form a useful companion volume to that which has been so well executed by Mr. Harrison.

# REPORTS AND PROCEEDINGS.

## GEOLOGICAL SOCIETY OF LONDON.

I.—ANNUAL GENERAL MEETING.—February 17th, 1882.—Robert Etheridge, Esq., F.R.S., President, in the Chair.

The Secretaries read the Reports of the Council and of the Library and Museum Committee for the year 1881. The Council expressed their regret that the hope of renewed prosperity which they had held out in their last Annual Report had hardly been fulfilled, the financial position of the Society being, for certain reasons, a little worse than at the beginning of the year. At the same time the number of Fellows was stated to be steadily increasing; and as this increase consists mainly of Contributing Fellows, the future prosperity of the Society was regarded as insured. The Council also expressed regret that the Catalogue of the Library had not met with the demand that they expected. The Council's Report further announced the awards of the various Medals and of the proceeds of the Donation Funds in the gift of the Society.

In presenting the Wollaston Gold Medal to Mr. H. Bauerman, F.G.S., for transmission to Dr. Franz Ritter von Hauer, F.M.G.S., Director of the Austrian Geological Survey, the President addressed him as follows:—

Mr. BAUERMAN,—In handing to you the Wollaston Medal for transmission to Franz von Hauer, I trust you will inform him that the Council of the Geological Society award this, their highest prize, in recognition of his valuable labours in connexion with the Geology of Austro-Hungary, and especially for his long-continued services in the investigation of extensive areas, and his numerous descriptive memoirs produced during the preparation of the Great Map of the Austrian Empire. Von Hauer has contributed no less than 100 papers and memoirs to geological literature, 25 of which are on palæontological subjects; he has paid particular attention to the fauna of the Hallstadt and Raibl beds, and to the Cephalopoda of the Eastern, or Austrian Alps. His descriptive pamphlets relating to the General Map of Austria are models of concise description as summarizing the results of the work of the Imperial Geological Survey. These results have also formed the basis of a general manual of Austrian Geology, which is the best guide we have to some of the most interesting parts of Central and Eastern Europe. Von Hauer has been attached to the Austrian Survey ever since its commencement in 1849; he succeeded Haidinger as Director in 1866. His great work is "Die Geologie und ihre Anwendung auf die Kenntniss der Bodenbeschaffenheit der Österr.-ungar. Monarchie," published in 1875. I have said enough, Sir, to enable you to inform Dr. Franz Ritter von Hauer of the high appreciation the Council have of his merits, and the satisfaction they have in recognizing them by awarding to him the Wollaston Medal.

Mr. BAUERMAN, in reply, said that he regretted that the compulsory absence of the Foreign Secretary, Mr. Warington W. Smyth, prevented his receiving this Medal from the hands of the President. He had much pleasure, however, in undertaking the office of transmitting to Dr. Franz von Hauer this testimony of the appreciation of his valuable labours on the part of the Geological Society. He called attention especially to the Geological Survey Map of Austria, the sheets of which were on the table, and which had been produced by the labours of the Survey under the direction of Franz von Hauer. Notwithstanding the difficulty of much of the country represented and the small scale of the Map, the details were admirably worked out, and the Map itself was one of the most beautiful ever produced.

The PRESIDENT then presented the Murchison Medal to Professor

Jules Gosselet, F.C.G.S., of the Faculty of Sciences of Lille, and addressed him as follows :—

Professor Gosselet,—The Council of the Geological Society has selected you to receive the Murchison Medal and part of the proceeds of the Murchison Fund, in recognition of your distinguished services to geological science. Your labours have extended over twenty-five years, and have been devoted to the elucidation of the history and physical structure of the north of France and Belgium, in the latter country, particularly, with relation to the Palæozoic rocks of the Ardennes, culminating in your researches into the structure of the Franco-Belgian Coal-field, so amply described and worked out in your "Esquisse géologique du Nord de la France." For this valuable work the French Academy of Sciences, in 1881, awarded to you the Bordin prize, the highest in their power to confer upon you. I must here mention, although but briefly, the nature of your researches. Your published papers or contributions to geological science number 22; I can only enumerate two or three which prominently stand out and show your extensive labours. In 1860-61 the Geological Society of France published your "Mémoire sur les terrains Primaires de la Belgique et du nord de la France." In the publications of the Brussels Academy of Sciences for the year 1853 appeared your paper "Sur les terrains Primaires de la Belgique." In 1873, in the 'Annales des Sciences Géologiques,' vol. iv., appeared your memoir on "Le système du Poudingue de Burnot, entre Dinant et Namur," and in the 'Bulletin' of the Academy of Sciences at Brussels, yourself and M. C. Malaise published your observations "Sur le terrain Silurien de l'Ardenne." In addition to your many papers, your work above named, 'Esquisse géologique du Nord de la France,' would place you in the front rank of observers and entitle you to high consideration. The nature and value of your investigations and the tendency of your researches led the Council to believe that the Medal founded by Sir Roderick Murchison would be worthily conferred upon you.

Professor Gosselet, in reply, said:—Monsieur le Président,—J'ai souvent regretté de ne pas connaître la langue anglaise; mais jamais autant qu'aujourdhui, où je me vois forcé de vous exprimer en un langage étranger ma reconnaissance pour le grand honneur que me fait le Conseil de la Société Géologique de Londres en me décernant la médaille Murchison. Vos récompenses sont les plus flatteuses que puisse recevoir un géologue étranger, parce qu'elles sont exemptes de toute idée d'école et de toute considération personnelle. Je suis particulièrement honoré que vous m'ayez jugé digne d'associer mon nom à celui de Murchison, du grand géologue qui a été un des fondateurs de la géologie des roches paléozoiques. Depuis mes premiers travaux géologiques, j'ai conçu une grande estime pour cet illustre savant, et dans bien des circonstances j'ai défendu sa classification des formations Siluriennes et Dévoniennes. Permettez moi d'associer à mes remercîments, la Société Géologique du Nord. En décernant l'année passée une médaille à M. Barrois et en m'en décernant une cette année, vous nous avez donné un haute marque de sympathie. Nous nous efforcerons de nous en montrer dignes.

The President next handed the Lyell Medal to Prof. J. W. Judd, F.R.S., Sec.G.S., for transmission to Dr. John Lycett, of Scarborough, and addressed him as follows :—

Professor Judd,—The Council have awarded the Lyell Medal and part of the proceeds of the Lyell Fund to Dr. John Lycett, in recognition of his patient and long-continued researches on Jurassic palæontology, especially those devoted to the critical history and description of the Great Oolite Mollusca of Minchinhampton, published in the Palæontological Society's volumes for the years 1850-55, in conjunction with Professor Morris; also for his supplementary monograph in the same publication, "On the Mollusca of the Stonesfield Slate, Great Oolite, Forest Marble, and Cornbrash." Besides these, Dr. Lycett has written (1871-79) a complete and important monograph of the British Trigoniæ for the same Society, in which he describes no less than 109 species; this splendid contribution to the history of a single genus of Mollusca is probably unsurpassed in any language; and when we know that the authors of all the memoirs published by the Palæontographical Society give their time and knowledge without remuneration, we may well reward as best we can, work done so well and so unselfishly. Dr. Lycett has contributed seventeen papers to the 'Annals and Magazine of Natural History;'

and fourteen to the 'Transactions of the Cotteswold Club,' and has published a Handbook of the Geology and Palæontology of the Cotteswold Hills. You will convey this Medal and award to Dr. Lycett, and assure him that, although he is not a Fellow of this Society, we are nevertheless not unmindful of the great service he has rendered to Jurassic palæontology.

Prof. JUDD, in reply, apologized in the name of Dr. Lycett for his absence on this occasion, which he said was due to the weak state of his health. At Dr. Lycett's request he represented him at the Meeting, and he read the following letter from Dr. Lycett:— "Scarborough, Feb. 10, 1882.

"Dear Mr. Judd,—I desire through you to express to the President and Fellows of the Geological Society my deep sense of the honour they confer upon me in presenting me with the Lyell Medal. I also wish to express my regret that infirmities connected with advance of years quite prevent my having the pleasure of being present upon this occasion. Even the little which I have been enabled to effect in the cultivation of palæontological science has always been to me a never-failing source of pleasure and satisfaction, qualified, however, by a regret that my means and opportunities have been so limited in their scope, and a conviction that all I have either accomplished or attempted is altogether insignificant in comparison with the immense field of research presented by nature to the student in palæontology.

"I remain, dear Mr. Judd, Yours truly and faithfully, John Lycett.

"*Professor J. W. Judd, F.R.S., F.G.S.*"

In presenting the balance of the proceeds of the Wollaston Donation Fund to Dr. Geo. Jennings Hinde, F.G.S., the PRESIDENT said:

Dr. HINDE,—The Council of this Society has awarded to you the balance of the proceeds of the Wollaston Fund as a testimony of their recognition of your researches in certain groups of the Invertebrata and upon Glacial phenomena in Canada, the latter carried on during a residence of seven years in that country, where your entire time was spent in geological research and gaining extensive knowledge of a large area of eastern North America, extending from Nova Scotia on the east to Nebraska on the west, and from the shores of Lake Superior to the Gulf of Mexico. Your researches on the Silurian fossils of the Niagara and Guelph formations, the Glacial phenomena of the peninsula of Western Canada, and on the Glacial and Interglacial strata of Scarboro' heights, near Toronto, are described in the Canadian Journal. Your discovery of Conodonts and the jaws of Annelids in the Ordovician strata near Toronto showed conclusively that they were as abundant in the Silurian and Devonian strata of North America, as in the rocks of the same age in Russia, where they had been described by Pander. This discovery of Annelid jaws proved the existence of this class, previously *supposed* to occur in the Palæozoic strata only from their tracks; it also showed their close relationship to existing errant Annelids. This was followed by your discovering similar Annelid remains in the Silurian strata of the West of England and in the Subcarboniferous rocks in Scotland. Lastly, your careful, learned, and elaborate researches upon the large collection of fossil sponges in the British Museum, at present in MS., would alone entitle you to the consideration of the Council. I therefore in their name hand you the balance of the proceeds of the Wollaston Fund, to enable you to carry on further research and to mark their high appreciation of your labours.

Dr. HINDE, in reply, said:—Mr. President,—I desire to express my hearty acknowledgments to the Council of the Geological Society for the honour which they have bestowed upon me, and to you, Sir, for the kind terms in which you have conveyed the award to me. I accept it with great gratification, for I regard it not only as a complimentary recognition on the part of the Council of the work which I have done, but also as a proof of their sympathetic encouragement of my future efforts. That I should ever accomplish anything which would lead to my receiving the Wollaston fund did not enter into my wildest dreams when I made my early attempts, some years since, in geological investigation in that grand field for practical study, the dominion of Canada. I commenced under the guidance of my esteemed friend and former teacher, Prof. Alleyne Nicholson, then of Toronto, to whom I am deeply indebted for those initiatory lessons in practical work which have since proved invaluable to me. It was not until after trying my prentice hand on various subjects that I was induced by one or two happy finds to adopt for my special study the task of searching after and elucidating the fossils of the lower forms of animal life which, either in themselves or in their component parts, are so minute as to require the microscope for their investigation. My experience in America taught me that in order to make fresh discoveries in palæontology, it was necessary to take into the field a good lens, as well as a hammer, so as to find those little fossils which, on account of their smallness, are passed over by other observers; but I did not expect that in this country, where every yard of ground almost had been subjected to scrutiny, much remained for discovery, even amongst these small objects. I am very glad to find myself disappointed in this belief; for the little which I have explored as yet in this country convinces me that in this line of research there is abundant work yet to be done; and stimulated by the mark of your encouragement which I have this day received, it will be my earnest effort and my hope, by patient study in this promising field, to contribute still further to the extension of the boundaries of science which it is the object of our Society to advance.

The PRESIDENT next handed the balance of the proceeds of the Murchison Donation to Prof. T. G. Bonney, M.A., F.R.S., Sec. G.S., for transmission to Prof. T. Rupert Jones, F.R.S., F.G.S., and addressed him as follows:—

Professor BONNEY,—The Council of the Geological Society has no ordinary pleasure in handing to you for Prof. Rupert Jones, F.R.S., the balance of the Murchison Donation Fund in recognition of the valuable services he has rendered to special branches of geological and palæontological science. His contributions to the history and palæontology of the Lower Invertebrata, especially the Rhizopoda and Ostracoda, have won for him European and world-wide fame. He contributed nearly 100 papers to various magazines and societies, especially the "Annals and Magazine of Natural History," between the years 1859 and 1880, and, with few exceptions, all bearing upon his favourite studies. In three of his many important communications he was associated with Mr. W. K. Parker, F.R.S.; and I may here mention his joint papers, "On the Nomenclature of the Foraminifera," "On the Rhizopodal Fauna of the Mediterranean compared with that of the Italian and some other Tertiary Deposits," and "On the Foraminifera from the Bryozoan Limestone of Mount Gambier, South Australia," all of the utmost value for the history of these minute organisms. I can only notice, from want of time, four or five papers by himself:—1 "On the oldest known Fossil (*Eozoon canadense*) of the Laurentian Rocks of Canada," etc.; 2. "On Recent and Fossil Bivalve Entomostraca"; 3. "On the Swiss Jurassic Foraminifera"; 4. "On the Entomostraca of the Carboniferous Rocks of Scotland"; 5. "On the range in time of the Foraminifera." I may refer also to his completion and editing of Lartet and Christie's 'Reliquiæ Aquitanicæ,' ranging from 1865 to 1875, to his new edition of Dixon's 'Sussex,' to his assisting in editing the 'Micrographic Dictionary,' to his editing the 'Arctic Admiralty Manual for the Nares Expedition in 1875,' to his famous Croydon Lecture, and to that most useful though small book, 'Syllabus, or Heads of Lectures for the use of Lecturers or Teachers,' by himself and Prof. Morris. Other subjects have likewise received his attention, as shown by his papers on the Primeval Rivers of England, and on the Diamond Fields of South Africa amongst many others. Fifteen of his papers have appeared in the Quarterly Journal of our Society. For such patient, good, and long-continued work, most of it without remuneration, the Council deem him eminently worthy of the award they offer for his acceptance.

Prof. BONNEY, in reply, said: —Mr. President,—It is with great regret that I find myself acting to-day as deputy for Prof. Rupert Jones, because his absence is caused, not by official duties or engagements yet more pleasant, but by rather serious illness. I am, however, glad to have the opportunity of expressing my sympathy with him under treatment which appears to me unjust,[1] my appreciation of him as a geologist, and my esteem for him as a man, especially for the reason that he has always been so ready to place his great stores of knowledge at the service of younger students. I proceed, then, to read the reply which he has entrusted to me:—"Feb. 17, 1882.

"Mr. PRESIDENT,—This unexpected honour awarded by the Council of the Geological Society to a worker among Foraminifera and Entomostraca and a teacher of geology among the rising generation, I venture to regard rather as an incentive to still more careful work and still more earnest teaching than as an honorarium for any work done or any good results yet attained. The endeavour to disseminate knowledge by teaching has not been without its pleasures, though the professional pay has ceased for want of sympathy with geology in some quarters. The palæontological work has always carried its reward with it, both in the fulfilment of a naturalist's duty and in the frequent friendly cooperation of fellow workers. The foremost of these is my distinguished friend Prof. W. K. Parker, who was associated with me by the Council some twenty years ago in a high compliment similar to that for which I now give you thanks. Another friend and fellow-worker, Mr. Kirkby, was honoured not long since with a similar tribute to his scientific worth and industry. To enjoy such associations is a reward in itself. To know that the Society appreciates what I have done and tried to do is in itself a reward also. To have this encouraging mark of its favour, as instituted by one of the best of geologists, and one of the best of my old friends, is a pleasure and a honour greater than I deserve."

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[1] This remark of Prof. Bonney's is in allusion to *the abolition* of the Chair of Geology in the Royal Military and Staff College, Sandhurst.—EDIT. GEOL. MAG.

In presenting to Prof. Charles Lapworth, F.G.S., of the Mason College of Science, Birmingham, one moiety of the balance of the proceeds of the Lyell Donation Fund, the President addressed him as follows:—

Professor LAPWORTH,—Those who know not your valuable contributions to palæozoic geology and palæontology have much to learn; probably no other author has so ably written upon the Graptolitidæ, or has taken a more comprehensive view of the history of life and development in the lowest rocks of the British Islands and Scandinavia than yourself. You have enriched the literature of palæozoic palæontology by fourteen or fifteen communications of the greatest value. Chief amongst them is your paper in our Journal on the Moffat series in 1878; no recent contribution to this branch of palæontology surpasses this in research. Most of your papers have been contributed to the GEOLOGICAL MAGAZINE, between the years 1870-81, and to the publications of the Glasgow and Edinburgh Geological Societies, most of which have an important bearing upon the history of the Rhabdophora, both zoologically and stratigraphically. I may mention your papers on the British Graptolites and their allies, and on an improved classification of the Rhabdophora, both in the year 1873; also, in 1876, your paper on the Scottish Monograptidæ, and your two philosophical papers on the Tripartite divisions of the Lower Palæozoic rocks, and on the correlation of the Lower Palæozoic rocks of Britain and Scandinavia. I believe you are now engaged in the preparation of another paper requiring considerable research; to aid you therefore in this, the Council have awarded you part of the proceeds of the Lyell Fund.

Prof. LAPWORTH, in reply, said:—Mr. President,—I am deeply sensible of the unexpected honour conferred upon me by the Council in making this award, and I beg to offer them my sincere thanks. I am especially grateful for the generous and flattering terms in which you, Sir, have referred to my labours and for the kindly and hearty manner in which the Fellows of the Society have received the mention of my name. My original work in geology in the past has been the delightful employment of such few hours as I have been able to snatch from the absorbing duties and avocations of a very busy life, and to me the charms of original research are so attractive that I feel pretty confident that such leisure time as I find at my disposal in the future will most certainly be devoted to the same pursuits. Next to the pleasure of original discovery itself is the profound satisfaction that springs from the knowledge that one possesses the interest and sympathy of one's fellow scientists. And here I have always felt that I have been more than ordinarily fortunate; for the Fellows of this Society have cheered me from the first with their kindly approval and encouragement. I look upon this award, as I did upon that which I received a few years ago, as distinct and tangible evidence of their continued interest in my work and their desire for its continuance, and I accept it in the spirit in which it is given. I am especially gratified that the present award is associated with the illustrious name of Sir Charles Lyell. His unbiassed conscientiousness in the accumulation of his facts, his fearless and earnest search for truth, and truth alone, and his calmness and modesty in the presentation of his magnificent results, have always made him appear in my eyes to be that of one of the geologists of the modern age most worthy of respect and imitation, and I feel a profound pleasure in being thus associated, however remotely, with his illustrious name. I can only trust that in the future which is left to me, that little which I shall be able to accomplish may be performed at least somewhat in his spirit, and along those lines which shall retain for me that which I regard as one of the proudest possessions of my scientific life—the sympathy and approbation of the Fellows of this Society.

The PRESIDENT then presented to the Rev. Norman Glass the second moiety of the Lyell Donation Fund, and addressed him as follows:—

Mr. GLASS,—The Council have awarded to you part of the proceeds of the Lyell Donation Fund in recognition of the valuable aid and services you have rendered in elucidating the history and internal structure of the British and Foreign Brachiopoda. The generous and talented assistance you have rendered to Mr. Davidson through your method of preparing for observation the interior anatomy of the Brachiopoda, for the publication of his great "Memoir" upon the British Palæozoic Brachiopoda, may, perhaps, only be known to a few; but those few so highly appreciate your disinterested aid, and the result of your work as depicted by Mr. Davidson, in the plates of the volumes of the Palæontographical Society, that the universal praise of your patience and industry has caused the Council to deem you richly deserving the award they ask you to receive to help you on still more with your valuable work.

Mr. GLASS, in reply, said:—Mr. President,—I need hardly say that I greatly esteem the honour which has been conferred upon me by the Council of this Society. The sense of this honour has been increased by my being associated with those gentlemen whose services to science you have just recognized, and I am more especially gratified in receiving this honour, Sir, from your hands, remembering the kindness and encouragement which I received from yourself and from the late Dr. S. P. Woodward more than twenty years ago, when I first began to take an interest in palæontology. Of course my work has been subsidiary to that of my honoured friend Mr. Davidson, whose scientific attainments and achievements are well known and esteemed by all who are interested in the study of geology. I have often, no doubt, during the three or four years of my labours with Mr. Davidson tried his patience; but then he has also sometimes severely tried mine; for he has persistently demanded proof, and still more proof, long after I have been convinced myself of certain peculiarities of structure. Very naturally, whilst manipulating a specimen, I often arrived at assurance myself before I could make such preparations as would convince an observer who had not been using my process for himself. However, Mr. Davidson's persistent demands for proof have only added to the assured correctness of the results obtained. Mr. Davidson I have found in many respects an admirable correspondent. Some of my friends seem to cherish the preposterous idea, that if you will only allow a letter to remain quiet long enough it will answer itself. This, however, is not the principle by which Mr. Davidson acts in his correspondence; and to the hundreds of communications I have sent to him I have hardly ever failed to receive an answer by return of post. In concluding my remarks I should like to express again the esteem with which I regard the honour which the Council of the Society has been pleased to confer upon me, and the hope I have that, inspired by their kindly recognition, I may do some further service to the science which I love so well.

The PRESIDENT next presented a portion of the proceeds of the Barlow-Jameson Fund to Baron Constantin von Ettingshausen, Professor of Botany in the University of Graz, Austria, and addressed him as follows:

Professor von ETTINGSHAUSEN,—It is with much pleasure that the Council of the Geological Society award to you the proceeds of the Barlow-Jameson Fund, in recognition of their high appreciation of your valuable contributions to Fossil Botany. Your services to this branch of science consist in the application of your knowledge of Recent Botany to the investigation of Fossil Plants, your extensive researches into the forms and venation of recent leaves, with the view of discovering characters which would assist in determining the affinities of the constituents of the Tertiary floras, and the success which has attended your experiments in exposing the remains of plants by freezing water which has been forced, under great pressure, into the matrix. The value of your labours is shown by your numerous memoirs on Fossil Plants, Palæozoic and Mesozoic, as well as Tertiary, published during the past thirty years, during which time you have enriched the literature of this science with no less than sixty papers, published chiefly in the Transactions of the Vienna Academy. We have also to take into consideration the important work which, in association with Mr. Gardner, you have accomplished relative to our English Tertiary Fossil flora contained in the clay beds of Bournemouth and the Isles of Wight and of Sheppey. This recognition of your services will show that your labours are appreciated and valued by British palæontologists, and may encourage you to the continued prosecution of the work you have undertaken, a work which your extensive acquaintance with Tertiary floras in other lands specially fits you to perform.

Prof. von Ettingshausen, in reply, said:—Mr. President,—I have to express my best thanks to the Geological Society for the honour conferred on me this day by the Council of the Society, and I am especially grateful to you, Sir, for the kind manner in which you have spoken of my works. If any encouragement was needed to induce me to continue the work upon which I am engaged, it would be found in the kind words which I have received from you to-day.

The President then read his Anniversary Address, in which he treated of the analysis and distribution of the British Jurassic fossils, with especial reference to their distribution in successive formations, which was elucidated by elaborate tables. Prefaced to the Address were some obituary notices of Fellows and Foreign Members of the Society deceased during the past year, including Sir P. de M. Grey-Egerton, Bart., Mr. R. Mallet, Sir Antonio Brady, Mr. E. W. Binney, Mr. Samuel Sharp, Professor Tennant, Mr. Charles Moore, Mr. Maclauchlan, M. A. Delesse, and Dr. Ami Boué.

The ballot for the Council and Officers was taken, and the following were duly elected for the ensuing year:—*President:* J. W. Hulke, Esq., F.R.S. *Vice-Presidents:* Prof. P. M. Duncan, M.B., F.R.S.; J. Gwyn Jeffreys, LL.D., F.R.S.; Prof. N. S. Maskelyne, M.A., M.P., F.R.S.; Prof. J. Morris, M.A. *Secretaries:* Prof. T. G. Bonney, M.A., F.R.S.; Prof. J. W. Judd, F.R.S. *Foreign Secretary:* Warington W. Smyth, Esq., M.A., F.R.S. *Treasurer:* Prof. T. Wiltshire, M.A., F.L.S. *Council:* H. Bauerman, Esq.; Prof. T. G. Bonney, M.A., F.R.S.; W. Carruthers, Esq., F.R.S.; Prof. P. M. Duncan, M.B., F.R.S.; R. Etheridge, Esq., F.R.S.; John Evans, D.C.L., LL.D., F.R.S.; J. Clarke Hawkshaw, Esq., M.A.; Rev. Edwin Hill, M.A.; G. J. Hinde, Ph.D.; J. W. Hulke, Esq., F.R.S.; J. Gwyn Jeffreys, LL.D., F.R.S.; Prof. J. W. Judd, F.R.S.; Sir J. Lubbock, Bart., D.C.L., M.P., F.R.S.; Prof. N. S. Maskelyne, M.A., M.P., F.R.S.; Prof. J. Morris, M.A.; S. R. Pattison, Esq.; Prof. J. Prestwich, M.A., F.R.S.; F. W. Rudler, Esq.; Prof. H. G. Seeley, F.R.S.; Warington W. Smyth, Esq., M.A., F.R.S., W. Topley, Esq.; Prof. T. Wiltshire, M.A., F.L.S.; Henry Woodward, LL.D., F.R.S.

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II.—February 22, 1882.—J. W. Hulke, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "Additional Discoveries of High-level Marine Drifts in North Wales, with Remarks on Driftless Areas." By D. Mackintosh, Esq., F.G.S.

The author begins with remarks on the importance of the marine drift-area (part of which he briefly described in his last paper), especially as regards its great extent, and the absence, so far as yet known, of similar high-level drifts (between 1000 and 1350 feet above the sea) in continental Europe, Asia, or North America. He lately traced the drift-area two miles further south than he had done during former explorations, its entire length being little short of five miles. In this paper he gives a detailed description of the numerous exposures of rounded gravel and stratified sand between the north end of Minera Mountain and Llangollen Vale, which, in some places, spread out into large flat expanses, but more frequently assume the form of knolls (frequently in perched positions), which rise up from beneath a covering of clay or peat. He dwells on the probable origin of the knoll-shaped configuration, including the theory of the precipitation of the drift from the stranding of floating ice, and the forcing up of previously deposited drift by the same agency, but inclines to the idea of the knolls having been chiefly accumulated by sea-currents. The author then describes several large areas in North Wales in which he could find no trace of rounded gravel, enters into a consideration of the causes of these driftless areas, and discusses the relative merits of the theory of their having been temporarily occupied by land-ice, and of the theory of non-exposure to tempestuous seas, or seas capable of rounding stones. He then gives an account of the discovery of granite boulders, associated with partially rounded drift, on the summit of Moel Wnion, 1900 feet above the sea (near Aber, North Wales); and endeavours to show that, while they could have been readily transported by floating ice (probably from Scotland, certainly not from Cumberland), the flow of land-ice from Snowdon, according to Ramsay, along the north face of Moel Wnion, must have prevented the access of northern land-ice to the summit of the latter mountain, while land-ice flowing from Cumberland to Anglesey (according to Ramsay) could not have been crossed by land-ice flowing south from Scotland to Moel Wnion. After referring to the outward direction of striæ on the north coast of North Wales, he concludes by giving a summary of facts and inferences.

2. "On some Sections of Lincolnshire Neocomian." By H. Keeping, Esq., of the Woodwardian Museum, Cambridge. Communicated by W. Keeping, Esq., M.A., F.G.S.

The construction of the Louth and Lincoln Railway, in the year 1872, led to the exposure of some fine sections of the Neocomian strata forming the base of the Lincolnshire Wold. From these beds the author had obtained a very large number of fossils, in many cases in an excellent state of preservation. As the sections are now becoming obscure, the author gives an account of the observations made by him at the time when they were best exposed, with lists of the fossils he obtained from them. He agrees with Professor Judd, who in 1867 first described these strata and determined their age, in his conclusions concerning the classification and correlation of the beds, but is disposed to regard the sands above Market Rasen as being a drift deposit, and not as belonging to the Lower Sand and Sandstone.

3. "Notes on the Geology of the Cheviot Hills (English side)." By C. T. Clough, Esq., M.A., F.G.S.

After a brief description of the physical structure of the district, the author passes on to its igneous rocks. These he groups under three heads—(1) the granite, (2) the lava flows and ash beds, (3) the intrusive dykes. The first occupies an area of about 24 square miles, it varies much in texture, is generally not conspicuously rich in quartz, and often contains hornblende as well as mica. It exhibits in places a curious streaked or banded structure due to local crushing. This is fully described. The lava flows (with ashes) are porphyrite; this is generally compact, sometimes glassy in structure, with scattered crystals of plagioclase, biotite, hornblende (sometimes augite), a little free quartz, and occasional olivine and apatite. Some peculiarities in these rocks are described. The intrusive dykes (3) consist of (*a*) coarse red porphyrite, (*b*) quartz porphyry, (*c*) felsite, (*d*) granite. The author considers that the porphyrite and granite (which are alternately intrusive one in another) belong approximately to the same geological epoch. This is the Lower Old Red Sandstone; and as pebbles of the granite as well as of the porphyrite occur in the Lower Carboniferous measures of the region, great denudation must have taken place prior to the latter epoch. The author also describes some basalt dykes which he considers to be of Miocene age.

## CORRESPONDENCE.

### DR. ROBERTS ON THE TWT HILL SERIES.

Sir,—I fear that in controversy Dr. Roberts occasionally allows too much freedom to his imagination. His reply to my criticisms on his communication relating to the conglomerates of the Twt Hill district and of Anglesey is in many respects far from accurate. For instance, he draws a plan of the Twt Hill Pit, places a line *A B* thereon, and states: "Prof. Bonney's section was taken along the line *A B*." There is nothing in our article (Q.J.G.S. vol. xxxv. p. 321) to warrant this assertion. My section was intended to be drawn roughly in the same line as Prof. Hughes's—but did not include so much, as I wished to call particular attention to the bands of conglomerate associated with the arkose (because at the time I considered this important as relating to the age of the rock). One of the bands rather high in the conglomerate did seem to me there to bear a resemblance to the bottom rock, but from subsequent visits I came to the conclusion that I had overestimated the resemblance. The diagram exhibited at the Society was a sketch of the pit (I have the original before me) exhibited to illustrate the same point. From where I stood Twt Hill was seen in the position indicated, but I never said the beds dipped under it, and there is nothing in the drawing to make this essential. The outcrop there shown is compatible with their passing on either side. I said the strike seemed E.N.E. Dr. Roberts's diagram makes it the same: how then could my diagram be drawn along *A B*? Sections are usually drawn approximately at right angles to the strike of the beds. I did not, however, regard this strike as perfectly accurate, for there were no exposures very well suited for measurement—and with a dozen pupils about one (among whom I believe was Dr. Roberts) asking all kinds of questions, it is difficult to avoid an error of a few degrees. The Cefn Cynryg grits mentioned in my paper of the present volume (p. 20) are not the same as the Careg Goch grits; that is to say, I am not speaking of the same localities. Possibly I may have fallen into some error in designating the places. In a thinly populated country, with names, and often a language, that to an English ear are as unintelligible as if they were Patagonian, and with a map that (from lapse of time) needs revision, it is difficult to avoid error. I still maintain that the materials of the Anglesey conglomerates are no valid proof in the case of the Twt Hill beds. I never intended to imply that every Cambrian conglomerate must contain felsite pebbles. The language of my article does not warrant the absurd "major premiss" which Dr. Roberts attributes to me. I was obviously speaking (I appeal to any unprejudiced reader to confirm this) of the conglomerates of the Bangor-Carnarvon region, which are full of felsite pebbles, and argued that it was very strange if this one conglomerate of that region, which did not contain felsite pebbles, should be Cambrian—and I pointed out that the absence of these in a distant region could not be adduced in explanation of their absence here. Put concisely this was my argument—"In the Bangor-Carnarvon district is a mass of felstone. This has largely supplied materials to the Cambrian and latest Pre-Cambrian conglomerates. In the same district, and near the felstone, are grits and conglomerates in which I do not find felstone fragments. Therefore I think they are not of the same age as the others. As I do not believe they can be later, I suppose they are earlier. The absence of felstone from conglomerates several miles from the mass of this rock does not seem to me to have much bearing on the subject."

As regards the last paragraph of Dr. Roberts's article, where he thinks he has made me contradict myself, I beg leave to request him to read my article (pp. 114–117) again, and he will see that I have never admitted the Twt Hill series as Cambrian. He forgets that I maintain that there is a considerable series (larger than that admitted by Prof. Hughes) beneath the Cambrian conglomerate of the Bangor area—Pebidian I suppose we may call it—and I think it more probable that the Twt Hill series belongs to this. The amount of alteration shown by the microscope is considerably greater than is usual in the Cambrian rocks. But really, to criticize fully this last paragraph, I should have to print it with a running commentary, so full is it of assumptions which I should dispute, or inferences which I maintain do not follow from my words. After the above example of his mode of conducting a controversy, Dr. Roberts must excuse me if I take no notice of any further communication which he may make on this subject. T. G. Bonney.

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## THE HEADON HILL SECTION.

Sir,—As I hope very shortly to have an opportunity of defending the views which I hold (in common with many foreign geologists) concerning the classification of the Isle of Wight Tertiaries, I should not have intervened in the controversy at the present moment, had I not felt myself compelled to protest against certain remarks made by the Rev. O. Fisher, in your last Number. As that gentleman expresses the opinion that my views are based on work "in the library and museum," I may be permitted to state that for more than twenty years I have devoted much time and labour to the study of the section in question. During that period I have measured it down, bed by bed, at least a dozen times, and it may be some comfort to my critics to inform them that the results arrived at, on various occasions, differ almost as greatly as do theirs from one another, and from the earlier sections of Dr. Wright, the Geological Survey, etc. Indeed, as I have stated in my paper, my prolonged study of the section has impressed me with a profound distrust as to the constancy of particular bands in these variable estuarine deposits. It is true that in addition to working at the English sections, I have visited the deposits of equivalent age in France, Belgium, Germany and other countries, that I have examined very large collections made from these deposits, and placed in Continental museums, and that I have even gone so far as to carefully study the works of foreign geologists which bear upon the question. But I hope that Mr. Fisher is the only geologist who will regard such action as constituting a disqualification on my part. In conclusion I must express my regret that your correspondent has such a poor opinion of the natives of the Isle of Wight as to suggest that the amenities of controversy are not to be expected from them. My ancestors for many generations lived in the island, and though, owing to circumstances over which I had no control, I cannot claim the distinction of being a native myself, yet I feel almost as jealous of any slur being cast upon their good name, as if I had not been born, just across the Solent, in the adjoining island of Great Britain. JOHN JUDD.

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## LAURENTIAN ROCKS OF DONEGAL.

SIR,—Permit me to withdraw the last paragraph in page 132 of my letter which appeared in the GEOLOGICAL MAGAZINE for March, and to express regret for having allowed myself to pen it.

GEOLOGICAL SURVEY OF IRELAND, EDWARD HULL.
14, HUME STREET, DUBLIN, *8th March*, 1882.

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## RATE OF DENUDATION OF THE LAND BY RIVERS.

SIR,—In answer to your correspondent, "McJames," writing from India, in your March Number, I may remark that Prof. Hopkins only published one paper on the "Transport of Erratic Blocks," and if your correspondent had referred to that paper he would have seen my calculation was correct, see page 233, vol. viii. Cam. Phil. Trans. line 3. Mr. Hopkins writes: "Therefore the moving force of a current, estimated by the volume of weight, of the mass, of any proposed form, which it is just capable of moving, varies as the 6th power of the velocity." As 729 is the sixth power of three, my calculation in your journal of an increase of 729 times was therefore perfectly correct, although by a printer's or a clerical error, the fifth power of 3 was inserted instead of the sixth power of 3.

In answer to question 1, I would refer to Phil. Mag. 1874, page 205, also to pages 446, 467, Geol. Mag. Dec. II. Vol. II. 1875, for my formulæ of increase of velocity of water with increase of quantity flowing, although slope is not altered. In answer to question 2, the Pluvial period is described, page 105, Quart. Journ. vol. xxiv. 1868, Tylor, Amiens Gravel. In answer to question 3, Hopkins's paper referred to is line 3, page 233, vol. viii. Cam. Phil. Trans. In answer to question 4, I explained in my letter how I arrived at the velocity being three times greater in the Pluvial period. But on page 63, vol. xxv. Quart. Journ. 1869, I give some cases in which the water flowing must have been 129 times greater than at present. At page 9, *op. cit.*, I suggest a rainfall of 300 inches in the Pluvial period.

I would also recommend Mr. McJames to read Login on the Ganges Valley, who refers to my papers in the Quart. Journ. Geol. Soc.

With regard to a wet period, M. Belgrand, of Paris, in his great work on the Gravels of the Seine, found, in 1871–2, that it was impossible to explain the size of the valleys and the deposits of gravel, without assuming a wet period in which the rainfall was twenty or twenty-five fold that at present in that part of France, thus confirming my view published in 1868. By the equation, page 467, Vol. II. Dec. II. Geol. Mag. the velocity increases the cube root of the increase of the quantity. If the rainfall was as stated by Belgrand and myself. the velocity of streams should be three times as much as at present, and the moving force would be as the sixth power. Then $3^6 = 729$, that is to say, where a stone now of 1 lb. weight can be moved, a stone of 729 lbs. weight could then have been lifted. In the Upper Ganges, running through a great gravel formation, the water-level never reaches now within 30 feet of the top of the banks. India exhibits the proof of a former Pluvial period.

London, *March* 11, 1882. A. Tylor.

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## SUPPOSED LAURENTIAN ROCKS.

Sir,—When I received the March Number of the Geol. Mag., I learned that the Philistines were upon me; but as I have so little time to spare, that I cannot even read the papers, my letter must necessarily be short.

Dr. Callaway visited the Wexford district without my maps, and left the most important sections unvisited, and that he does not know my work is evident from what he has written about it. I suggested he should visit West Galway; because, in that country, he would find the rocks so well exposed that his supposed unconformability in the Wexford rocks southward of Greenore would be then explained. I cannot understand where he obtained the obsolete maps; as, after my maps of the Wexford district were published, I could not obtain copies of the old ones from any of the authorized Irish publishers.

To Professor Hull's letter it is unnecessary to make any reply.

Gorey, *March 6th*, 1882. G. H. Kinahan.

## THE BRIDLINGTON CRAG.

SIR,—In your Number for December, 1881 (p. 538), Mr. Lamplu introducing what he had to say about Bridlington and Dimlingt by quoting from the first part of my memoir, "On the new Pliocene period in England," my assertion that the Bridlingt shells lived where they occur, adds that this is "very doubtful."

What I endeavoured in that memoir to show was, that at the ti when, at the beginning of the great submergence, the land-ice fou its way to the sea, while that was as yet confined to the east side England, and the Crag shells, *Nucula Cobboldiæ* and *Tellina obliq* had not become extinct, the basement clay of Holderness was moraine, the ice which formed it being so much of that envelopi the wold as issued through the Humber; that as this ice beg to retreat before increasing submergence (to advance afterwa during emergence, while forming the chalky clay, in direction which, in consequence of the altered inclination England, was quite different to that of its retreat, so that it avoid Holderness), it uncovered this moraine, whereupon the Bridlingt and Dimlington mollusca established themselves upon it, becomi imbedded in the thin beds of mud and sand which were then thro down on it, and which, perhaps, became some of them buried in t moraine by slight alternations in advance or retreat of the contiguo ice as it was (on the whole) retiring; that afterwards, during t emergence, and when the ice giving rise to the moraine of t chalky clay was pushing in its altered direction, and invading E Anglia and the East Midland Counties, a stream of ice from t North of Yorkshire (reinforced by the land-ice which crossed t Pennine at Stainmore and brought the Shap blocks found in t purple clay of East Yorkshire) came southwards down the east si of Yorkshire, and gave rise by its moraine to the purple clay; a that in doing so it passed over this early moraine which had be deserted by the ice during the progress of the submergence, breaki up and twisting up into the old moraine the thin beds containi the remains of the mollusca which had established themselves up it. Not only did it do this, but it carried off part of the old moraine and incorporated this into its own, the lower part of this, which chalk is plentiful, being largely made up of the older morai reconstructed, and sheets of the old moraine thus carried off are Dimlington and near the site of the Talbot Inn to be seen alternati with sheets of the newer moraine in the lower part of the latter.

So far from what Mr. Lamplugh had to show invalidating m assertion that the shells lived where they occur, his descriptio appear to me in the fullest way, as far as they go, to confirm n only this assertion, but the whole process which I have traced.

*February* 6, 1882. SEARLES V. WOOD.

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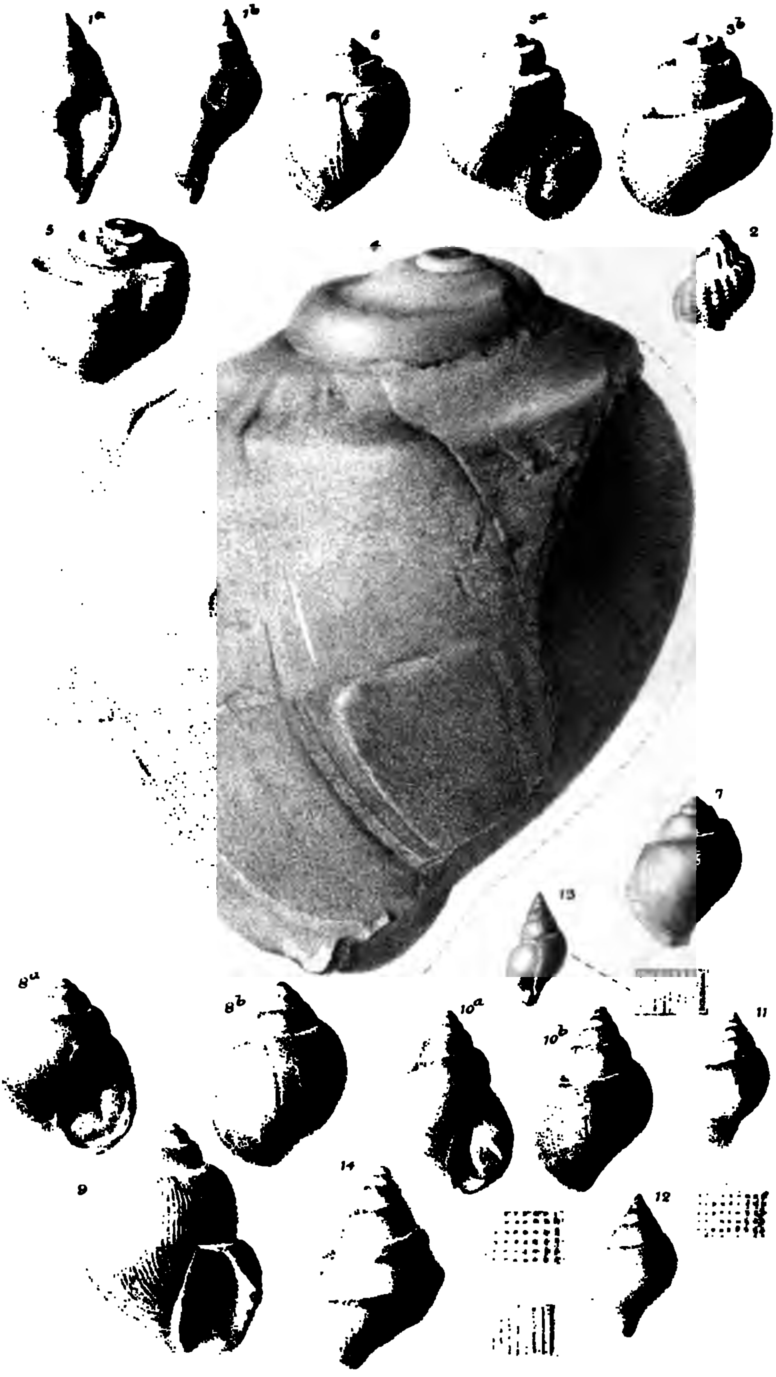
## ERRATA IN THE FEBRUARY NUMBER, 1882.

p. 94, line 10 from bottom, *for* "Upper White Lias," *read* "Upper Lias."
p. 96, *for* "Transactions of the Bath Literary and Philosophical Association," *re*
"Proceedings of the Bath Natural History and Antiquarian Field Club."



Oxfordian and Lower Oolite Gasteropoda, Yorkshire.

Edward del. et lith. West Newman & Co. imp.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE II. VOL. IX.

No. V.—MAY, 1882.

## ORIGINAL ARTICLES.

### I.—CONTRIBUTIONS TO THE PALÆONTOLOGY OF THE YORKSHIRE OOLITES.

By WILFRID H. HUDLESTON, M.A., F.G.S.
President Geologists' Association.

(*Continued from page* 151.)

(PLATE V.)

### Genus FUSUS, Lamarck, 1799.

THE number of fossil species of *Fusus* is considerable, but they do not date back from a very high antiquity. None are enumerated by Tate and Blake from the Lias of Yorkshire. Certain forms from the Upper Lias of Normandy, referred by Deslongchamps to *Fusus*, have not been accepted as such, and the first of the genus admitted by D'Orbigny is *Fusus nodulosus*, Desl., from the Great Oolite of Langrune. Even this almost comes within the genus *Brachytrema* of Lycett (Ool. Moll. p. 24), instituted to include some small turbinated forms with highly ornamented whorls and a short oblique canal.

*Fusus multicostatus*, M. and L., from the Great Oolite of Minchinhampton, has a better claim to be admitted into the genus. This species is recognized by Brauns as occurring in what may be regarded as the equivalents of the Great Oolite in N.W. Germany. But the most thorough *Fusus*, perhaps, of the Jurassic rocks is *F. Piette*, Héb. and Desl., from the Callovian of Montreuil-Bellay.[1]

Seeing that there is little encouragement to expect a *Fusus* in the Superior Oolite of Yorkshire, it is not altogether without hesitation that I have introduced

#### 1.—FUSUS, sp. Pl. V. Figs. 1*a*, 1*b*.

*Description.*—Specimen from the Dogger (Zone 1) Peak (Blue Wyke). My Collection.

| | |
|---|---|
| Length | 27 millimètres. |
| Width | 15 ,, |
| Spiral angle | 65°. |

The shell tapers towards either extremity. Body-whorl, including the canal, about 3·5 times the length of the rest of the spire. No umbilicus. Aperture oval-elongate and curving anteriorly. The state of conservation is such that no closer description can be given: it is difficult to say how far the smooth appearance of the spire is to be relied upon as a character.

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[1] Bull. Soc. Linn. Norm. v. p. 172, pl. viii. fig. 6.

The specimen is unique, and was found by the late Peter Cullen. It has been suggested that the shell might be that of a *Pterocera*s.

### Genus PURPURINA, D'Orbigny, 1847, Prod. i. p. 270.

Defined by Deslongchamps, 1860 (Bull. Soc. Linn. Norm. vol. v. p. 136).

The history of *Purpurina* is rather singular. D'Orbigny gives a short diagnosis in the Prodrome, and names several species from the Bajocian, Bathonian, Callovian, and Oxfordian; all of which, perhaps, belong to the genera *Brachytrema* and *Purpuroidea* of Lycett. In the "Terrains Jurassiques," as is well pointed out by Deslongchamps,[1] numerous figures of *Purpurina* are given in the atlas, most of which belong to the genus *Eucyclus* (*Amberleya*). In the text D'Orbigny says nothing about the genus *Purpurina*, nor is there a word of description of any of the species figured.

It is clear that the able author of the Paléontologie Française abandoned his offspring in the most heartless manner. Fortunately there is just one figure of a most characteristic form, *P. bellona*, D'Orb. (T. J. pl. 331, figs. 1 and 3),[2] from the Inferior Oolite of Bayeux, and this has been accepted both by Piette (Bull. Soc. Géol. de la France, 2nd series, vol. xviii. p. 587) and by Deslongchamps for the type of a genus, which, as defined by them, has relations on one side with *Turbo*, and on the other with *Cerithium* and *Purpura*.

"These shells," says Deslongchamps (vol. *cit.* p. 176; p. 24 of the separate Memoir on the Fossils of Montreuil-Bellay), "are characterized by a thick test, a small groove more or less pronounced in front of the mouth, especially in early life, by an umbilical slit of very limited extent, by the whorls of the spire presenting longitudinal[3] ribs more or less marked, cut by transverse striæ, a strong keel, or at least a very pronounced 'ressaut,' forming upon the whorl a 'meplat' towards the suture, which is deeply cut: finally a body-whorl much more developed than the others." These features are not in every case to be made out, owing to the conditions of preservation.

In the Inferior Oolite of Dundry[4] the genus is fairly represented, and it occurs sparingly in the Great Oolite, Cornbrash and Kelloway Rock, above which latter I cannot trace it in England. The

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[1] *op. cit.* p. 140.

[2] To complicate matters still more, the type species is not enumerated in the Prodrome list as a *Purpurina*, but as a *Turbo*, "munie de fortes ondulations longitudinales, et de nombreuses cotes transverses. France, Bayeux (Calvados)." As if this was not enough, we have also (Prod. i. p. 299) *Trochus bellona*. This is quite a different thing; it is referred to in the text of the T. J. p. 284, and figured, pl. 316—figs. 1-4—whilst *Turbo bellona*, the future type of the genus *Purpurina*, is omitted altogether from the text.

[3] Deslongchamps here uses the word *longitudinal* in a sense which some would call *transverse*.

[4] Cf. Tawney, Dundry Gasteropoda, p. 3 of separate Memoir.

Inferior Oolite of Bradford Abbas and of Normandy and the Callovian of Montreuil-Bellay seem to be the head-quarters of this group of small and well-marked shells, of which there are two species or varieties in the Yorkshire beds now under consideration.

### 2.—PURPURINA ELABORATA, Bean, Morris and Lycett, 1850, var. *Bajocensis*. Plate V. Fig. 2.

1850. *Turbo elaboratus*, Bean MS.; Morris and Lycett, Gt. Ool. Moll., Part 1, p. 116, pl. xv. fig. 2.
1869. *Purpurina elaborata*, Bean; Brauns Mitl. Jura, p. 168.
1875. *Turbo elaboratus*, Bean; Phillips, G. Y., 3rd edition, p. 259.

*Bibliography, etc.*—This specimen was described by Morris and Lycett from Gloucestershire (*op. cit.* p. 64, pl. ix. fig. 27) as well as from Yorkshire specimens. The Gloucestershire specimen is in an excellent state of preservation, and may be seen at the Museum in Jermyn Street. It comes from the Great Oolite, and may be regarded as a distinct variety. The Yorkshire specimen is from the Scarborough Limestone (zone 3), and is only indifferently preserved. The type is in the Bean Collection at the British Museum. In describing this latter specimen (p. 116) the authors observe that "the base is rounded, so that it neither exhibits the thickened lip of *Littorina*, nor the basal produced form of *Turbo*." It is clear, therefore, that the generic position of *T. elaboratus* must have been regarded as somewhat uncertain. The shell described below, though not exactly similar to either of the types, is sufficiently near to be placed with them.

*Description.*—Specimen from the Dogger (zone 1) Peak (Blue Wyke). Leckenby Collection.

| | |
|---|---|
| Length (restored) | 16 mm. |
| Width | 12 ,, |
| Ratio of body-whorl to entire shell | 62 : 100. |
| Spiral angle | 75°. |

Shell turrited. Whorls 4–5, body-whorl tumid. Upper area of whorl flattened, and slightly sloping forwards. Strong longitudinal (*i.e.* transverse according to some authors) ribbing decussated spirally so as to produce nodes on the ribs—a characteristic of this group and eminently so of this variety. The ribbing is not carried quite down to the base of the shell.

N.B.—In this specimen the decussation of the ribs in the whorls of the spire is altogether obliterated, except in the penultimate, where it is slightly shown.

*Relations and Distribution.*—This form, or something very like it, is sparingly but widely distributed throughout portions of the Inferior Oolite. At Bradford Abbas, which may be regarded as the head-quarters of this group of univalves in the English Bajocian, is a *Purpurina*, far from common, which serves to connect this variety with *P. bellona*, regarded as the type of the genus.[1] So that *P. bajocensis* and *P. bellona* are not so far removed as might be imagined.

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[1] There are several species of *Purpurina* in the Inf. Ool. of Bradford Abbas. The most common is a very coarsely marked shell, hitherto unnamed, as far as I know.

On the other hand, *P. elaborata* from the Great Oolite of Minchinhampton has the longitudinal costæ rather bolder and wider apart.

### 3.—PURPURINA CONDENSATA, Héb. and Deslongch. 1860. Plate V. Figs. 3*a*, 3*b*.

"*Turbo liratus*," Bean MS.
1860. *Purpurina condensata*, Heb. and Desl., Foss. de Montreuil-Bellay, p. 26, pl. i. fig. 8 *a-d*.

*Bibliography, etc.*—The authors describe their species as being nearly related to other Purpurinas from the Callovian of Montreuil-Bellay, which seems to be as rich in this peculiar group as the Inferior Oolite of the Anglo-Norman basin.

*Description.*—Specimen from the Kelloway Rock of Scarborough (zone 5). Bean Collection, Brit. Mus.

Only three whorls of this specimen are left. The ornaments are faint, owing to its being almost in the condition of a cast. As far as one can judge under these circumstances the longitudinal (*i.e.* transverse of some) ribbing is somewhat similar in character to the Inferior Oolite species (Fig. 2), and similarly decussated. But the intercostal spaces are wider, and the whole form is on a much grander scale. As there is no shell covering the columellar region, the appearance of an umbilicus is stronger than usual in *Purpurina*, where a slight umbilical slit alone is visible. For the same reason the slight anterior channel, only seen in well-preserved specimens, is not visible in this instance.

*Relations and Distribution.*—This form also occurs in the Cornbrash of Scarborough, and has usually been quoted in the lists as *Turbo elaboratus*. Decidedly scarce in both formations. It is obviously related to some of the varieties of *P. condensata*, Héb. and Desl., distinguished from the other Purpurinas by the stoutness of the costæ, and may perhaps be regarded as its representative in the Callovian of Yorkshire. Some might prefer to describe the shell as a large form of *P. elaborata*, from which in all probability it was descended.

## Genus NATICA.

The species included below in this genus might in some cases be referred to *Euspira*, Ag., in others to *Littorina*, but on the whole it seems best to describe them under *Natica;* the more so that the genus *Euspira* of Agassiz has, it seems to me, been applied in a somewhat opposite sense by different writers.

Besides the species enumerated, there are other forms, principally from zones 1, 2 and 3, which might perhaps be entitled to specific distinction—small ill-preserved specimens which one hardly knows how to treat.

In Yorkshire the genus is fairly represented in the lower beds of the Inferior Oolite, though, with one remarkable exception, the forms are small. In the "Cornbrash" and Oxfordian generally the forms are very small, and not numerous, but in the Coral Rag *Natica* revives in great force (see Corallian Gasteropoda).[1]

---

[1] A small *Natica* is described by Lycett from the Cornbrash, which I cannot find in any collection. As it may be necessary to publish a supplemental plate at the end of this Memoir, further reference is deferred.

### 4.—NATICA CINCTA, Phillips, 1829. Pl. V. Figs. 4 and 5.

1829 and 1835. *Natica cincta*, Phil. G. Y., tab. iv. fig. 9, p. 101.
1850. *Natica Leckhamptonensis*, Lycett, Proc. Cottes. Nat. Club, vol. i. p. 77.
1854. *N. cincta*, Phil. = *N. Leckhamptonensis*, Lyc., Morr. Cat. p. 262.
1875. *N. cincta*, Phil. G. Y. (3rd ed.), tab. iv. fig. 9, p. 325.

*Bibliography, etc.*—This remarkable shell was first figured by Phillips, without a description, as from the Coralline Oolite of Malton, along with "*Echinus*" *germinans*, and "*Clypeus*" *semisulcatus*. The distinction between the Coralline Oolite of the Malton district and the Inferior Oolite of the Castle Howard district (zone 2) was not made known in those early days, when, if a man had a bagful of fossils, collectors did not inquire too closely whence they were obtained. But, as Phillips figured the fossil from the Coralline Oolite, it was naturally presumed that *N. cincta* belonged to that formation.

In 1850 the Rev. P. B. Brodie, in a paper "On the Geology of the Neighbourhood of Grantham,"[1] speaks of a very large *Natica* characteristic of the Inferior Oolite of Denton, of which casts only were known. This was described by Lycett as a new species under the title of *N. Leckhamptonensis*, with the following diagnosis: "Spire elevated, whorls convex, the last enormously expanded, upper surface of the whorls rounded and sulcated; aperture very effuse, orbicular. Only casts known. A gigantic species."

In 1854 Morris, with his usual sagacity, perceived the close connexion between *N. cincta*, Phil., and *N. Leckhamptonensis*, Lyc., but, misled by Phillips, quotes it from the Coralline Oolite. Moreover, under the then prevailing impression that the Denton Limestone was Great Oolite (contrary to the opinion expressed by Brodie), he quotes it from the "Great Oolite" of Lincolnshire, as well as from the Inferior Oolite of Gloucestershire.

It matters little whether the shell be called *cincta* or *Leckhamptonensis*, the great point is to show that these really are one and the same species. As the notion of *N. cincta* being a Coralline Oolite form is tolerably well stereotyped in the public mind,[2] some evidence to the contrary may be demanded. *Firstly*, after many years experience of public and private collections from the Yorkshire Corallian, I never could find any specimen which at all corresponded with Phillips's figure. *Secondly*, it became known to me that casts and squeezed specimens of a large tabulate *Natica* had been taken from some old workings in the Inferior Oolite limestone near Castle Howard. Mr. Reed of York, who knows that district so well, shared my suspicions that these were bad specimens of Phillips's *N. cincta*. By the kindness of Professor Miall I have been able to examine the type specimen. The matrix at once shows that it belongs to the Bajocian and not to the Corallian limestones of Yorkshire. It is a fawn-coloured sandy limestone, which has considerable resemblance to a rock in North Oxfordshire, whence magnificent shells of "*Leckhamptonensis*" have been obtained lately.

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[1] Proc. Cottes. Nat. Club, vol. i. p. 56.

[2] Like so many Phillipsian errors, which seem to have a singular fascination for some people.

*Description.*—Specimen from the Inferior Oolite limestone of t Castle Howard district (zone 2). Collection of the Leeds Phi sophical Society.

TYPE SPECIMEN REFIGURED.

| | |
|---|---|
| Length (restored) | 104 mm. |
| Width | 95 ,, |
| Ratio of body-whorl to entire shell | 79 : 100. |
| Spiral angle, about | 120°. |

Shell subangular, nearly as wide as long, spire moderately elevat Whorls probably 4–5, increasing in regular proportion with gr rapidity, so as to produce an enormous expansion of the body-wh All the whorls are distinguished posteriorly by a sloping tabul surface, which rises slightly to meet the strong keel at the angle the whorl. The keel, which in the body-whorl obtains imme proportions, imparts an angular character to all the whorls, wh otherwise are convex, almost tumid, and devoid of regular ornam except the rugose lines marking the stages of growth. There however, towards the middle of the body-whorl, a spiral ba developed in this specimen by weathering, which indicates peculiarity less strongly marked in specimens from other distri but which in the case of this particular shell has served to fix name.

The shell substance of the body-whorl, now consisting entirel spar, has a thickness of 5 mm. The angular outline is not re sented in the cast (see right-hand upper corner of Fig. 4), whic rounded as in the well-known casts of *N. Leckhamptonensis.* aperture is extremely wide. There is hardly any umbilicus, shell substance being 20 mm. thick in this region. When thi dissolved away, the corresponding space in the cast is very w so that the connexion between the almost corkscrew-like form Denton and this shell is not so obvious at first sight. It serve show the danger of describing a fossil from a cast.

*Another specimen* from the Dogger (zone 1), Bean Coll. B. (Plate V. Fig. 5.)

| | |
|---|---|
| Length | 23 millimètres. |
| Width | 22·5 ,, |
| Ratio of body-whorl to entire shell | 72 : 100. |
| Spiral angle | 128°. |

The dimensions are very different, but the proportions and gen shape are sufficiently near to induce me to regard this as in probability a small specimen of *N. cincta.*

*Relations and Distribution.*—It must be borne in mind that the t specimen is, as regards Yorkshire, unique both in size and condit Specimens are very scarce, and none have, as far as I know, b procured from the Mount Pleasant Quarry, the principal loca for Inferior Oolite fossils. Whether we regard the fact fro stratigraphical or a palæontological point of view, the appearanc this singular and enormous shell, on *the same horizon* through England, north of the Avon, is almost a portent. There are m indications which serve to connect the 2nd zone of the Yorkshire Inferior Oolite with the Lincolnshire Limestone, and this again would seem to be somewhere about the horizon of the Oolite Marl of the Cotteswolds, where also *N. cincta* is abundant and of good size. Instead of a fossil, which was supposed (*vid. supra*) to range from I. O. through G. O. into C. O., the larger forms are confined to one limited horizon in the I. O. throughout England north of the Avon; the finest specimens, with the shell on, coming from Combe Hill near Deddington (North Oxfordshire), where it occurs along with *Am. Murchisonæ, Terebratula fimbria* and *Spiropora straminea* (the original Millepore).[1] There are no signs of it in the Anglo-Norman basin that have come under my notice, nor anywhere on the Continent.

### 5.—NATICA ADDUCTA, Phillips, 1829. Plate V. Fig. 6.

1829, 1835. *Natica adducta*, Phil., G. Y. pl. ix. fig. 30.
1850. *Natica adducta*, Phil., Morris and Lycett, Gt. Ool. Moll. p. 112, pl. xv. figs. 17, 17*a*.
1852 ? *N. adducta*, Phil., D'Orb. T. J. p. 189, pl. 289, figs. 4 and 5.

*Bibliography, etc.*—The history of this rather common species has been slightly complicated, from the fact that Phillips gives two very different figures of "*Natica adducta*," viz. pl. ix. fig. 30, and pl. xi. fig. 35. The former is from the Scarborough Limestone (zone 3), the latter from the Dogger (zone 1). They look very different, but since Morris and Lycett refigure the specimen from the Scarborough Limestone as the type, it may be as well to regard it in that light. This form is not rare in all three zones of the Inferior Oolite of Yorkshire. Although D'Orbigny refers to Phillips's pl. xi. fig. 35, his own figures are more like the form one usually finds, and which is figured in the accompanying Plate.

*Description.*—Specimen from the Dogger (zone 1) Peak (Blue Wyke). Collection of the Scarborough Phil. Soc.

| | |
|---|---|
| Length | 23 mm. |
| Width | 19 ,, |
| Ratio of body-whorl to entire shell | 70 : 100. |
| Spiral angle | 92°. |

Shell somewhat longer than wide; oval, not umbilicated. This specimen, of which the spire is unusually well and sharply preserved, has six whorls, which increase moderately and regularly with a sutural angle of very slight inclination. Upper part of each whorl flatted, and very slightly channelled; sides of the whorl steep and very slightly convex. The general contour regular and slightly angular. Lines of growth broad and fairly preserved. No punctæ visible.

*Relations and Distribution.*—The very singular manner in which many of these *Naticas* run into each other, when one looks over a large series, leads one to suppose that more names may have been given than the necessity of the case requires. This appears to be a very average form, and with very slight differences has a wide range; possibly, as far as lists go, its presence may be masked under some synonym. It reaches a fair size in the Scarborough Limestone, where the specimens are less sharply preserved, and present a more softened outline than those from the Dogger. No umbilicus.

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[1] Judd, Geology of Rutland, p. 25.

### 6.—NATICA ADDUCTA, Phil., var. CANINA. Plate V. Fig. 7.

1829. ? *Natica adducta*, Phil., G. Y. pl. xi. fig. 35.

*Description.*—Specimen from the Dogger (zone 1) Peak (Blue Wyke). Leckenby Collection.

| | |
|---|---|
| Length | 20 mm. |
| Width | 16 ,, |
| Ratio of body-whorl to entire shell | 70 : 100. |
| Spiral angle | 87°. |

Proportions nearly the same as Fig. 6; but with a slightly smaller spiral angle. The flatted portion of the whorls is narrower, and in this specimen at least the channelling is less marked. Moreover, in the body-whorl there is a tendency to the development of a median keel, which is in marked contrast to the smooth outline of the body-whorl in Fig. 6.

The absence of an umbilicus seems to distinguish this from *N. Lorieri*, D'Orb. (T. J. p. 190, pl. 289, figs. 6, 7).

### 7.—NATICA PROXIMA, sp.n. Pl. V. Figs. 8*a*, 8*b*.

*Description.*—Specimen from the Dogger (zone 1) Peak (Blue Wyke). Leckenby Collection.

| | |
|---|---|
| Length | 25 millimètres. |
| Width | 18·5 ,, |
| Ratio of body-whorl to entire shell | 70 : 100. |
| Spiral angle | 75°. |

Shell oval, subumbilicate. Whorls six, regular, smooth, and slightly tumid. The flat area of the upper part of the whorl is narrow, and the border bevilled off, thus reducing the tabular area, so characteristic of the preceding species, to a minimum. Aperture oval, and rather compressed. There is a well-marked umbilical groove with a very considerable callus on the inner lip.

Fig. 9. Specimen from the Dogger. My Collection. This is too much compressed for accurate measurement. The outline and proportions are nearly the same as in Fig. 8. The umbilical groove and patulous inner lip are strongly shown. As *N. proxima* is the only species from these beds showing any considerable trace of callus or of umbilicus, I venture to class this singular specimen provisionally with that species.

The peculiar state of fossilization has developed the lines of growth to such an extent as to impart quite a sculpture to the surface of the whorls. The age of the shell may have favoured this, but the feature is, in the main, a subsequent development, and has no structural significance.

*Relations and Distribution.*—This shell, which is intermediate in its spiral angle between *Natica adducta* and *Natica punctura* (*Bajocensis*), presently to be described, has also affinities with *Natica canina*, in a very slight tendency to a median keel in the body-whorl, whilst in the strongly patulous inner lip and marked umbilical groove it differs entirely from all other forms of *Natica* occurring in the Inferior Oolite of Yorkshire, where it probably represents D'Orbigny's *N. Pictaviensis* (Terr. Jurass. p. 191, pl. 289, figs. 8–10). Indeed the Dogger shell is almost intermediate between *N. Pictaviensis* and *N. Lorieri* (*op. cit.* p. 190), both of which species are described as being umbilicated and patulous.

### 8.—NATICA PUNCTURA, Bean, 1839. Pl. V. Figs. 10*a*, 10*b*, 11 and 12.

1839. *Littorina punctura*, Bean, Magazine of Natural History, vol. iii. p. 62, fig. 23.
1850. *Natica punctura*, Bean, Mor. and Lyc., Gt. Ool. Moll. p. 112, pl. xv. figs. 18, 18*a*.
1852. ? *Natica Bajocensis*, D'Orb., T. J. p. 189, pl. 289, figs. 1, 3.

*Bibliography, etc.*—The following is the original notice: "Shell turbinated, finely striated longitudinally and transversely. . . . . . Whorls (6) rounded and well divided, the body-whorl occupying one-half the length of the shell. Aperture elliptical, pillar lip thick and a little flattened, outer lip very thin: length nearly ¾ inch, breadth ½ inch. The only specimen procured from the Cornbrash; but in the Inferior Oolite at Peak Hill it is not uncommon."

The type of *L. punctura* therefore must be sought in the Cornbrash of Scarborough. Morris and Lycett figure a specimen from the Scarborough Limestone[1] (zone 3). Some persons might be disposed to challenge Bean's identification of the Cornbrash and Dogger fossils as belonging to the same species.

*Description*, var. *Bajocensis*, Figs. 10*a*, 10*b*.—Specimen from the Dogger (zone 1) Peak (Blue Wyke). Leckenby Collection.

| | |
|---|---|
| Length | 25·5 mm. |
| Width | 16·5 ,, |
| Ratio of body-whorl to entire shell | 60 : 100. |
| Spiral angle | 65°. |

Shell oval-elongate, not umbilicate. Whorls 6 or 7, increasing regularly; smooth, turbinated, and rounded off near the suture. Sutural channel distinct, but narrow. Aperture subelliptical, and contracted posteally: inner lip straight. Not the least trace of an umbilicus.

The surface of the whorls has a sort of punctate structure (see Fig. 10), being the result of decussation of the fine lines of growth with equally fine spiral lines, producing a mesh-like appearance. N.B. The specimen is in the condition usual to fossils from this bed (the *Nerinæa*-bed), viz. shell substance replaced by spathic iron, with skin and lining of brown oxide.

*Type form* (Fig. 11).—Specimen from the Cornbrash (zone 4), Scarborough. Leckenby Collection.

There is no material difference in the proportions of this specimen (selected for the sake of its condition rather than for its size) and that from the Dogger. Owing to the difference in the replacing substance,—the usual waxy-looking calcite of the Cornbrash,—the punctate structure assumes a different aspect. This probably was the aspect which presented itself to Bean.

---

[1] N.B. Misled by Phillips's mistake, these authors refer to it as "Bath Oolite."

(Fig. 12). Specimen from the Kelloway Rock (zone 5), Scarborough. Leckenby Collection.

In this case the proportions are practically the same as in the previous cases, but the state of preservation is one of unusual excellence. The specimen has been obtained from the calciferous grit, or "chert-bed."[1] It displays an ornamentation consisting of flat ribands divided by narrow and shallow sulci (see enlargement). This is probably a faithful picture of the original surface of the shell, such as may be seen in so many existing *Naticas*. Another stage of fossilization would probably reveal that sort of decussation of these lines of growth with spiral lines which has so large a share in producing *punctate* structure. The eye of faith, aided by a powerful magnifier, might perchance see it here, but neither the artist nor myself have been able to do so. Yet it may exist and only requires a developer to bring out the picture.

*Relations and Distribution.*—Bean, as we know, had no doubt about the fossils from the Dogger and the Cornbrash being practically the same species. This form is perhaps the commonest species referred to *Natica* in the Dogger, and is far from rare in the 2nd and 3rd zones, though there the punctate character is not well shown owing to the *status* of the fossils. A species so plentiful and with such a large vertical range must needs be tolerably abundant in the Bajocian beds of other regions. Partly for this reason I cannot but think that *N. Bajocensis*, so abundant at Burton Bradstock and elsewhere, is the representative, at any rate of the variety of *N. punctura*, so common in the three zones of the Inferior Oolite of Yorkshire. The general contour of the shell and of the whorls is the same. Moreover, the *proportions*, which I take to be by far the most important element in the diagnosis of these unornamented shells, correspond almost exactly with those given by D'Orbigny (*op. cit.* p. 189). There remains the difficulty of the punctate structure. The typical *N. Bajocensis* is not described by the author as punctate, whereas the Dogger shells always are, though not as a rule from the two other zones of the Inferior Oolite of Yorkshire. I believe this punctate condition to be very much a matter of *status*, being developed under certain circumstances and in certain kinds of matrix, and that its presence or absence is not always to be regarded as a crucial test of the relations of a fossil.

Should it be deemed desirable to separate the Inferior Oolite form from that of the "Cornbrash" and "Kelloway," the former would become *N. Bajocensis*, D'Orb., the latter remaining as before.

### 9.—NATICA CALYPSO, D'Orbigny, var. TENUIS. Plate V. Fig. 13.

1852. *Natica Calypso*, D'Orb., T. J. p. 202, pl. 222, figs. 9, 10.

*Description.*—Specimen from the Lower Calcareous Grit (zone 7), Cayton Bay. Leckenby Collection.

| | |
|---|---|
| Length .................................. | 15·5 mm. |
| Width .................................. | 8·5 ,, |
| Ratio of body-whorl to entire shell............ | 61 : 100. |
| Spiral angle .............................. | 50°. |

---

[1] See Introduction.

This is almost in the same state of preservation as Fig. 12, the matrix and replacements being very similar. The lines of growth are exquisitely preserved, but no punctæ are visible.

*Relations and Description.*—This shell has the turbinated whorls and other indications attributed to *N. punctura* from the Lower beds. There is one important difference—the spiral angle is 15° less. The "species" seems to be passing into something else. It should be noted that Gasteropoda of this horizon are usually small, whilst the more genuine *Naticas* are absent throughout the Lower Calcareous Grit of Yorkshire. This form comes very near to *Natica Calypso*, D'Orb., common in the Oxfordian of the Ardennes, both in size and contour, but the French shell is less slender.

With this elongated form the species referred to *Natica* terminate, and surely it is stretching the limits of the genus to the utmost when *Natica cincta* (Fig. 4) and *N. tenuis* (Fig. 13) are both included within its ample folds.

### CLOUGHTONIA, gen. nov.

Shell short, conical, and solid, with a widish base, shell substance thick. Whorls about five, flat and angular. Body-whorl more or less bicarinated with slight depression of the intervening space. Surface smooth or ornamented with rugose lines of growth (dependent partly perhaps on the state of preservation). Aperture ovate to ovate-oblong, rounded anteriorly. Pillar nearly straight and with little or no callus.

This genus has been constituted in order to receive a peculiar and limited group of shells of which *Cloughtonia cincta*, presently to be described, may be taken as the type. It appears to be intermediate between the *Naticas* and so-called *Chemnitzias*, some species being more nearly allied to the latter, some to the former; it occurs where the conditions may be regarded as peculiar, and to a certain extent "estuarine." After disappearing from the Jurassic rocks of this country above the Inferior Oolite, the genus reappears in the Portlandian of Bucks and the Vale of Wardour, where two species were described by me provisionally under "*Pseudomelania*" (see Gasteropoda of the Portland Rocks, GEOL. MAG. Sept. 1881, p. 389).

Named from Cloughton Wyke, a bay between Scarborough and Peak, where the type species was first discovered, and where it is not uncommon in zones 2 and 3.

### 10.—CLOUGHTONIA CINOTA, Phillips, 1829. Plate V. Fig. 14.

1829, and 1835. *Phasianella cincta*, Phil., G. Y. pl. ix. fig. 29, p. 123.
1847. *Phasianella cincta*, Phil., D'Orb. Prod. de Pal. Strat. p. 267.
1830. *Natica* (*Euspira*)? *cincta* Phil., Morris and Lycett, Gt. Ool. Moll. p. 113, pl. xv. fig. 20.
1875. *Phasianella cincta*, Phil., G. Y. 3rd ed. p. 259.

*Bibliography, etc.*—Quoted in Phillips's 1st and 2nd editions from "the Gray Limestone of Cloughton and Brandsby"; in the third edition from the "G. O."[1] of the same localities. The specimen figured by Morris and Lycett is Phillips's original. Their figure is a faithful portrait of a large and much deformed specimen now in the collection of the Yorkshire Philosophical Society.

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[1] As this "G. O.," so often used in the third edition, is very apt to impose upon the unwary, it is as well to state that it does not mean *Great Oolite*, but *Grey Oolite!* From bad to worse one might say, as the Grey Limestone (zone 3) is very rarely oolitic.

*Description.*—Specimen from the Scarborough Limestone (zone 3). Leckenby Collection.

| | |
|---|---|
| Length | 29 mm. |
| Width | 18 ,, |
| Ratio of body-whorl to entire shell | 59 : 100. |
| Spiral angle | 56°. |

Shell short, conical, not umbilicated: spire with a sharp apex. Whorls 5 or 6, angular and carinated in the neighbourhood of the suture, which is channelled. Body-whorl strongly bicarinated, the keel near the suture being obtuse, the median keel sharp and prominent; intervening area depressed. No impression of the median keel upon the internal cast. Aperture oval, subject to a slight angularity of the outer lip. No umbilical groove, and but little trace of callus.

*Relations and Distribution.*—This very curious species seems to stand by itself in the Yorkshire beds, and its generic position has been variously defined. *Natica*, *Euspira*, *Phasianella*, all have served in turn. It represents on this horizon a group of forms to which I have referred in constituting the genus. Regarding the whole group as Natico-chemnitzoid, this species has more affinities with the latter than with the former. The character of the aperture favours this view, but still more the bicarinated whorl and median depression. Compare also *Chem. abbreviata*, Röm.

*Cloughtonia cincta* is pretty common in all three zones of the Inferior Oolite of the Yorkshire coast, and has been found on the same horizon in the Castle Howard district. The largest specimens known to me are from the Dogger. It occurs also in the Lincolnshire Limestone at Ponton, but beyond that I have not traced it at present, though it might be looked for in parts of North Oxfordshire, as at Combe Hill.

## EXPLANATION OF PLATE V.

Fig. 1. *Fusus?* sp. Dogger, Blue Wyke. My Collection. *a* front view; *b* back view.
,, 2. *Purpurina elaborata*, Bean, var. *Bajocensis*. Dogger, Blue Wyke. Leckenby Collection.
,, 3. *Purpurina condensata*, Héb. and Desl. Kelloway Rock, Scarborough. Bean Collection, British Museum. *a* front view; *b* back view.
,, 4. *Natica cincta*, Phillips. Type Refigured. Whitwell Oolite, near Castle Howard. Collection of the Leeds Philosophical and Literary Society.
,, 5. *Ibid.* Small specimen. Dogger, Blue Wyke. Bean Collection, British Museum.
,, 6. *Natica adducta*, Phillips. Dogger, Blue Wyke. Collection of the Scarborough Philosophical Society.
,, 7. *Ibid. canina*, var. Dogger, Blue Wyke. Leckenby Collection.
,, 8. *Natica proxima*, sp.n. Dogger, Blue Wyke. Leckenby Collection. *a* front view; *b* back view.
,, 9. *Natica proxima?* Aged specimen, with lines of growth strongly brought out. Dogger, Blue Wyke. My Collection.
,, 10. *Natica punctura*, Bean—? *N. Bajocensis*, D'Orb. Dogger, Blue Wyke. Leckenby Collection. *a* front view; *b* back view.

FIG. 11. *Ibid.* Typical form. Cornbrash, Scarborough. Leckenby Collection.
„ 12. *Ibid.* Kelloway Rock, Scarborough. Leckenby Collection.
„ 13. *Natica Calypso*, D'Orb., var. *tenuis*. Lower Calcareous Grit, Cayton Bay. Leckenby Collection.
„ 14. *Cloughtonia cincta*, Phillips. Scarborough Limestone, Cloughton Wyke. Leckenby Collection.

(*To be continued.*)

## II.—THE WINGS OF PTERODACTYLES.[1]

By Professor O. C. MARSH, M.A., F.G S.;
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THE first Pterosaurians discovered were recognized as flying animals, but were thought to be bats. As soon as their general structure became known, they were classed with the Reptiles, although it was considered possible that their power of flight was due to feathers. Later, their bones were mistaken for those of Birds by various experienced anatomists, and others regarded them as sharing important characters with that group. Some anatomists, however, believed that the fore limbs of Pterodactyles were used for swimming, rather than for flight, and this view has found supporters within the present decade. A single fortunate discovery, made a few years since, has done much to settle the question as to the wings of Pterodactyles, as well as their mode of flight, and it is the aim of the present article to place on record some of the more important facts thus brought to light.

The specimen to be described was found in 1873, near Eichstädt, Bavaria, in the same lithographic slates that have yielded *Archæopteryx*, *Compsognathus*, and so many other Jurassic fossils known to fame. This specimen, which represents a new species of the genus *Rhamphorhynchus*, is in a remarkable state of preservation. The bones of the skeleton are nearly all in position, and those of both wings show very perfect impressions of *volant membranes* still attached to them. Moreover, the extremity of the long tail supported a separate vertical membrane, which was evidently used as a rudder in flight. These peculiar features are well shown in Fig. 1, which represents the fossil one-fourth the natural size.

The discovery of this unique specimen naturally attracted much attention at the time, and many efforts were made to secure it for European museums. The writer was then at work on the toothless Pterodactyles which he had recently found in the Cretaceous of Kansas, and believing the present specimen important for his investigations, sent a message by cable to a friend in Germany, and purchased it for the museum of Yale College, where it is now deposited.

### THE WING MEMBRANES.

A careful examination of this fossil shows that the patagium of the wings was a thin smooth membrane, very similar to that of modern bats. As the wings were partially folded at the time of entombment, the volant membranes were naturally contracted into folds, and the surface was also marked by delicate striæ. At first sight, these striæ might readily be mistaken for a thin coating of hair, but on closer investigation they are seen to be minute wrinkles in the surface of the membranes, the under side of which is exposed. The wing membranes appear to have been attached in front along the entire length of the arm, and out to the end of the elongated wing finger. From this point the outer margin curved inward and backward, to the hind foot.

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[1] Communicated by the author. This article appeared in Silliman's American Journal of Science, for April, 1882 (vol. xxiii. No. 106).

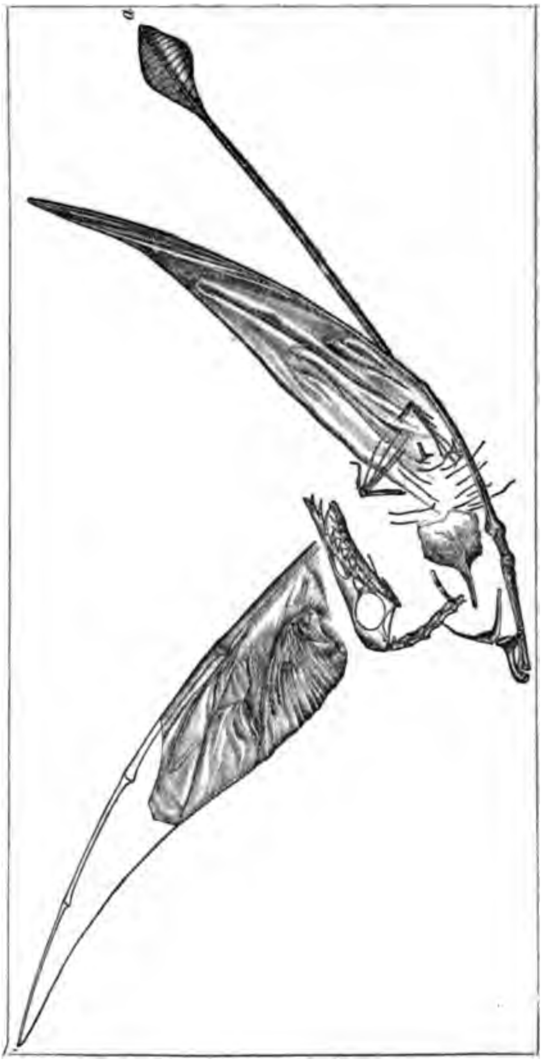

FIG. 1. *Rhamphorhynchus phyllurus*, Marsh. One-fourth natural size.

The animal lies upon the back, and the under surfaces of the wing membranes are exposed. The caudal membrane is seen at *a*.

The membrane evidently extended from the hind foot to near the base of the tail, but the exact outline of this portion cannot at present be determined. It was probably not far from the position assigned it in the restoration attempted in the cut given below, Figure 3. The attachment of the inner margin of the membrane to the body was doubtless similar to that seen in bats and flying squirrels.

In front of the arm, there was likewise a fold of the skin extending probably from near the shoulder to the wrist, as indicated in Figure 3. This fold inclosed a peculiar bone (pteroid), the nature and function of which will be discussed below in considering the osteology of this part of the skeleton.

### THE CAUDAL MEMBRANE.

The greater portion of the tail of this specimen was free, and without volant attachments. The distal extremity, however, including the last sixteen short vertebræ, supported a vertical membrane, which is shown in Figure 1 (*a*), and also in Figure 2. This peculiar caudal appendage was of somewhat greater thickness than the patagial membrane of the wings. It was rhomboid in outline, and its upper and lower portions were slightly unequal in form and size. The upper part was kept in position by a series of spines, sent off one from near the middle of each vertebral centrum, and thus clearly representing neural spines. The lower half also was strengthened by similar spines, which descended from near the junction of the vertebræ, and hence were homologous with chevron bones. These spines were cartilaginous, and flexible, but sufficiently firm in texture to keep the membrane in an upright position.

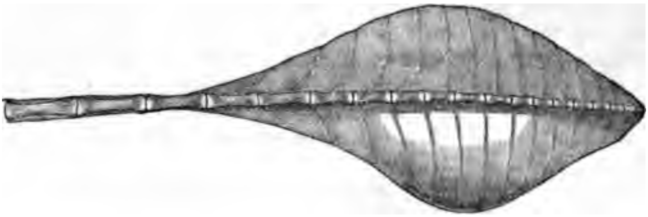

FIG. 2.—Caudal extremity of *Rhamphorhynchus phyllurus*, Marsh; natural size. Seen from the left side.

### THE SCAPULAR ARCH.

The osteology of the scapular arch and wings of Pterodactyles involves many interesting points, some of which have been discussed by anatomists from Cuvier to those of the present day, but with little agreement of opinion. The cause of this diversity of opinion is mainly due to the fact that the specimens examined have been either too small or too imperfect for accurate determination of their more obscure parts. Fortunately, the museum of Yale College has among its specimens of Cretaceous Pterodactyles (some 600 in all), quite a number with the scapular arch and wing-bones nearly perfect, and in position. These specimens were nearly all of gigantic size, having in life a spread of wings from fifteen to twenty feet. They were also destitute of teeth, and belong to the order *Pteranodontia.* Probably their great size induced special modifications of the scapular arch, which is here far more complicated than in any other members of the group.

In the Jurassic Pterodactyles, the scapula is usually bird-like in general form and proportions, the upper or distal extremity being free and compressed. This is the case in the specimen here described. The scapula and coracoid may be coössified, as in the present fossil, or remain more or less separate. No clavicles have yet been found. The sternum here shows no distinct facets for sternal ribs.

In the Cretaceous genus *Pteranodon*, and probably also in some of the other gigantic forms from deposits of this age, the scapula and coracoid were not only solidly united, but the pectoral arch was further strengthened, (1) by the ankylosis of several vertebræ, and (2) by the robust scapulæ articulating on opposite sides of the common neural spine of these vertebræ. This is virtually a repetition of the pelvic arch, on a much larger scale. The sternum also is massive, and shows well marked facets for the sternal ribs. This peculiar method of strengthening the scapular arch has not been observed in any other vertebrates.

## The Wing Bones.

The three principal bones of the arm (humerus, radius, and ulna) present such similar characters in all Pterodactyles that they need not be considered here in detail. It is important, however, to bear in mind that the ulna, although but little larger than the radius, contributes the greater share of direct support to the enormously developed wing finger, which is on the outer or ulnar side of the hand. As this position has been a question of discussion among anatomists, it may be well to state, that the writer bases his opinion upon this point on the results of an examination of the best preserved specimens in European museums, as well as nearly all known in this country. The latter specimens settle the question beyond doubt.

The views expressed by anatomists in regard to the bones of the wrist and hand of Pterodactyles are almost as various as the specimens investigated. Some of the restorations of these parts that have been published from time to time, and repeated in text books, have done much to propagate errors, and little to clear away the serious difficulties in the case. The main facts in regard to the carpus now known may be briefly stated as follows:

In all Pterodactyles, there are two principal carpal bones, placed one above the other. These sometimes show indications of being composite, but their constituent parts have not been satisfactorily determined. On the inner side of the wrist, articulating with the distal carpal, there is a smaller bone which has been called the "lateral carpal." In addition to these three bones, some American Pterodactyles have on the inner side three ossicles, which may be sesamoid bones. Two of these have been seen in a few Jurassic forms in Europe. Beside these, there is often found on the radial side of the wrist, and sometimes attached to it, a long, slender styloid bone, having a rounded articular head on its carpal extremity. This is the so-called "pteroid bone," to which allusion has already been made above. This bone and the "lateral carpal" which supports it are usually placed by anatomists on the outer or ulnar side, but American specimens prove conclusively that they belong on the radial side.

The nature of the so-called pteroid bone has been much discussed, but without a satisfactory conclusion. After a careful study of many specimens, the writer is disposed to regard it, not as an ossified tendon, but as a part of the first digit, or thumb, which is often considered wanting in Pterodactyles. According to this view, the "lateral carpal" would probably be the metacarpal of the same digit. In favour of this interpretation, it may be said:—

1. That the position and structure of this appendage of the carpus correspond closely with that of the first digit in some other reptiles, for example, *Iguanodon.*

2. The "lateral carpal" unites both with the distal carpal and with the "pteroid" by very free, well-defined articulations.

3. In American specimens, the "lateral carpal" stands nearly at right angles to the wrist, and the "pteroid" is much bent near its articular end.

4. In no Pterodactyle known is there any remnant of a digit outside the wing finger, where the membrane might be expected to retain it.

5. This view would make the wing finger the fifth digit, the same to which the membrane is attached in the hind foot.

Perhaps the strongest objection against this interpretation is the number of phalanges in the respective digits of the hand. These, however, are not constant in the known Pterodactyles, and they vary much in other reptiles which have the digits highly specialized. This subject will be more fully discussed by the writer elsewhere.

According to the above interpretation, there are five digits in the hand of Pterodactyles, although not the five often given in restorations. The first digit, the elements of which have been considered, undoubtedly supported a membrane in front of the arm. The second, third, and fourth are small, and armed with claws. The large wing finger is the fifth, corresponding to the little finger of the human hand.

The metacarpal bones are much elongated in the Pterodactyles with short tails, and quite short in those, like the present specimen, that have the tail long. The metacarpal of the wing finger is always large, and robust, while those of the claw-bearing digits are usually quite slender. In *Pteranodon,* the second metacarpal is a slender thread of bone, throughout most of the length, while the third and fourth are attenuated splint bones, incomplete above.

The phalanges of the three middle digits are quite short, and the terminal ones supported sharp claws. The wing finger has four greatly elongated phalanges, the last being a styloid bone, without a claw. This digit is well shown in the right wing represented in Fig. 1, and also in the restoration, given below, Fig. 3.

In the restoration here attempted, the writer has endeavoured to reproduce (1) the parts actually present or clearly indicated in the specimen described, and (2) those which the former seemed to require to complete the outward form in life. The membrane at the base of the tail may have been somewhat less in extent, and the fold of the skin above the fore-arm either more or less developed than here represented, but the facts now known render the outlines here given more than probable. The hands are represented with the palms forward.

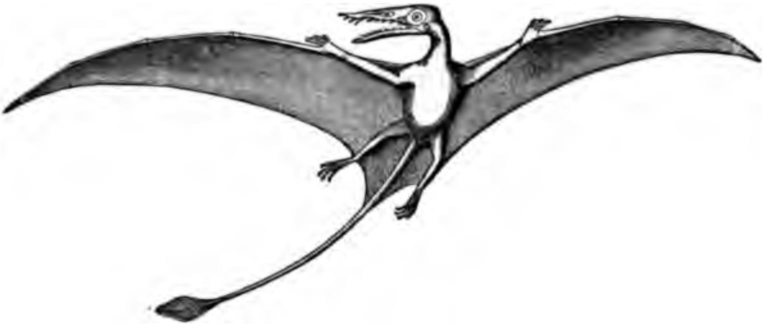

Fig. 3.—Restoration of *Rhamphorhynchus phyllurus*, Marsh.
One-seventh natural size.

The present species appears to be most nearly related to *Rhamphorhynchus Gemmingi*, von Meyer, from the same geological horizon, and near the same locality. That it is quite distinct, however, is shown, aside from the difference in size, by the complete ankylosis of the scapula and coracoid, and by the fifth digit of the hind foot being well developed, and having three phalanges. In the name *Rhamphorhynchus phyllurus*, here proposed for the species, the latter designation refers to the leaf-shaped caudal appendage, which appears to be one of its most characteristic features.

For the long delay in the description of this important European specimen, the writer can only plead *l'embarras des richesses* nearer home.

Yale College, New Haven, *March* 14, 1882.

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## III.—Note on the So-called " Hypersthenite " of Carrock Fell, Cumberland.

By Chas. O. Trechmann, Ph.D.

THROUGH the kindness of Mr. J. J. Harris Teall, F.G.S., I have been enabled to examine a hand-specimen of the above rock, gathered by himself at a point about half-way between the village of Mosedale and the summit of Carrock Fell. In general appearance it coincides with the white or grey variety of the hypersthenite of

Mr. J. C. Ward,[1] and which is described by him generally as "a coarsely crystalline compound of plagioclase felspar and hypersthene, with scattered grains of titaniferous iron oxide, and more or less quartz," remarking that "the hypersthene may be replaced by a hornblendic mineral or may occur in conjunction with it." It is a rock of rather coarse grain, consisting macroscopically of dull white crystals of plagioclase felspar with a greenish or bluish-green cast, some parts clear and vitreous with twin striations; very dark olive-green diallage in irregular grains, occasionally forming crystalloids with definite outline up to one-quarter of an inch in length, and rarely with any distinct metallic lustre on the cleavage faces (Mr. Teall states that the metallic lustre is pronounced in the weathered parts of the rock); large black grains and octahedrons of magnetite, perhaps in part ilmenite; a considerable quantity of white or greyish quartz in large grains; a soft micaceous decomposition product of paler colour than the diallage; lastly, a few minute elongated hexagonal crystals of a transparent light grass-green and rather soft mineral, which appears to be apatite.

The felspar is kaolinized on the weathered side of the specimen, leaving the diallage in a soft brownish-green altered condition, apparently serpentinized.

The microscopical analysis of a section cut from the specimen gave the following result:—

1. Plagioclase, probably labradorite, in large crystals, which were highly altered to a yellowish fine-grained substance, with aggregate polarization, and here and there intersected by fine veins of chlorite or serpentine, leaving clear and perfectly fresh portions made up of broad twin lamellæ, crossing one another in two directions. The dark microliths so common in labradorite are wanting. 2. Diallage in irregular patches, finely striated by cleavage fissures and dark interpositions. Faint cleavages in other directions also visible. Some parts, especially near the edges, were without interpositions. No twins. Colour pale brown, no pleochroism, active polarization, like augite. Occasionally a lamellar polarization, probably due to alteration. In sections more or less parallel to the klinopinacoid the position in which extinction took place between crossed Nicols gave angles varying between 23½° and 30½° with the vertical axis, *i.e.* direction of striation, of the crystals. No hornblende in conjunction with diallage. 3. Hornblende (?). A few minute grains were strongly pleochroitic, from bluish-green to yellowish-green, distinct cleavage and a somewhat rough surface. Extinction gave 9° with the direction of vertical axis. This may be hornblende. 4. Serpentine. A large portion of the augitic or hornblendic constituents of the rock is more or less completely altered to bright green serpentine, slightly pleochroic with aggregate polarization; a part may be chloritic. 5. A micaceous mineral is represented by a small number of minute irregular grains with wavy black striations. Dichroism distinct, dark bluish-green and yellowish brown. Extin-

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[1] On the Granitic, Granitoid and Associated Metamorphic Rocks of the Lake-district. Pts. iii.—v. Quart. Journ. Geol. Soc. vol. xxxii. (1876) p. 21.

guishing parallel with the striæ. 6. Quartz, interstitial in large quantity running in irregular bands through the section. It frequently had the broken-up appearance of quartz in "Schriftgranit." Minute fluid lacunæ with fixed and mobile bubbles. The high percentage of silica in Mr. Ward's analysis is hereby easily accounted for. 7. Magnetite in large crystals and irregular grains. 8. Apatite. A few colourless grains with regular outline agreed with the microscopic appearance of this mineral. A chemical test revealed the presence of phosphoric acid. Olivine was not observed.

With exception of the serpentinized portions, the number and size of the fragments of the oblique diallage preponderated to such an extent over anything that might be construed as hypersthene that the rock from which our specimen was taken seems undoubtedly to be a gabbro and not a hypersthenite. The question of the existence of the latter in the Carrock Fell district cannot, however, be regarded as solved, until a more extended examination has been made of the different occurrences of this interesting rock.

## IV.—SUPPLEMENT TO A CHAPTER IN THE HISTORY OF METEORITES.

By WALTER FLIGHT, D.Sc., F.G.S.

(*Continued from p.* 170.)

### 1877, January 3rd (Sunrise).—Warrenton, State of Missouri. [Lat. 38° 50′; Long. 91° 10′.][1]

A sound like that of a cannon ball passing through the air was heard by four observers near Warrenton. On looking up they saw an object falling, which struck a tree, breaking off the limbs, and then coming to the ground with a crash. The observers were fifty or sixty mètres distant from the spot where it fell. The snow was melted where it fell. From the fragments found, it appears to have had a conical form, and to have been about eighteen inches in length. The pieces, although warm, were easily handled. It is estimated that the stone weighed about one hundred pounds, but only about from ten to fifteen pounds weight have been preserved.

In one specimen the fibres of some of the branches are found adhering to the rough crust of the stone, and these delicate fibres show not the slightest sign of having been heated. No luminous phenomena attended the fall, which appears to have been slow; "it was no doubt a meteorite well spent in its rapid motion through the atmosphere." Its direction, as far as it could be ascertained, was from N.W. to S.E.

The stone differs in a marked degree from the one just described, although it also is pisolitic and fell only a few days previously. It closely resembles the Ornans meteorite, which fell 11th July, 1868, and the results of Dr. Smith's analysis closely accord with those found by Pisani[2] on analyzing that stone.

The crust in this case is unusually thick, being in some places from two and a half to three and a half millimètres in thickness.

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[1] J. L. Smith, *Amer. Jour. Sc.* 1877. xiii. 243; and xiv. 222.

[2] *Compt. rend.* 1868, lxvii. 663.

The interior has a very dark uniform ash colour, is soft, and is easily crushed. The density of the stone is 3·47; the troilite forms 3·51 per cent. of the stone and the nickel-iron 2·01 per cent.

By treatment with acid it was found that there were present:—

| | | |
|---|---|---|
| A. Soluble silicates | =80·40 | per cent. |
| B. Insoluble silicates | 19·60 | |
| | 100·00 | |

which contained respectively:—

| | A. | B. |
|---|---|---|
| Silicic acid | 33·02 | 56·90 |
| Iron protoxide | 37·57 | 10·20 |
| Alumina | 0·12 | 0·20 |
| Chromium oxide | —— | 0·33 |
| Lime | trace | 7·62 |
| Magnesia | 28·41 | 22·41 |
| Soda | 0·07 | 1·00 |
| Nickel oxide | 1·54 | |
| Cobalt oxide | 0·31 | |
| | 101·04 | 97·66 |

The chromium appears to be in the form of chromite, amounting to 0·5 of that mineral; and the nickel oxide to be a constituent of the soluble silicates. The nickel-iron, which is present in very small quantity, contained

Iron = 88·51; Nickel = 10·21; and Cobalt = 0·60 = 99·32.

The mineral constitution of this meteorite was calculated to be made up of:—

| | |
|---|---|
| Olivine minerals | 76·00 |
| Bronzite and pyroxenic minerals | 18·00 |
| Nickel-iron | 2·00 |
| Troilite | 3·50 |
| Chrome-iron | 0·50 |

The proportion of olivine present in this stone is unusually high.

### 1877, January 23rd, 4 p.m.—Cynthiana, Harrison Co., Kentucky.[1]

At the date given above a brilliant meteor was seen traversing Monroe County, Indiana, in a S.E. direction, about thirty-five degrees above the horizon; it was also seen by several persons in Decatur County of the same State, lat. 39° 27′; long. 85° 28′, where it disappeared just as it seemed to touch the earth, not more than a quarter of a mile distant. It fell about sixty miles distant. Apparently it was not seen in the State of Ohio, but in the State of Kentucky it was observed over a considerable territory. The phenomenon culminated in the usual noises heard in the heavens. Fortunately one observer, an intelligent farmer, heard a solid body strike the ground; he walked immediately to the spot and dug the stone out from a depth of thirteen inches.

The stone weighs six kilogrammes; it is wedge-shaped, with one portion of it very extensively and regularly pitted, while the rest is comparatively smooth. The crust is dull black and is as perfect as when the stone fell. There was a fresh broken spot of two or three square centimètres which was evidently made prior to the fall, a few small specks of the melted matter adhering to the surface. The texture of the meteorite is of the harder brecciated variety, and when broken presents a mottled surface, identical with that of the Parnallee stone, which it resembles in every other particular. The specific gravity of the two meteorites is identical, viz. 3·41.

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[1] J. L. Smith, *Amer. Jour. Sc.* 1877, xiii. 243; and xiv. 225.

The Cynthiana stone, when treated with hydrochloric acid, gave:—

| | |
|---|---|
| A. Soluble silicate | 56·50 |
| B. Insoluble silicate | 43·50 |

which were found to have the following composition:—

| | A. | B. |
|---|---|---|
| Silicic acid | 33·65 | 57·60 |
| Iron protoxide | 30·83 | 11·42 |
| Alumina | 0·11 | 0·43 |
| Chromium oxide | —— | 0·38 |
| Lime | trace | 5·70 |
| Magnesia | 34·61 | 23·97 |
| Soda | —— | 1·24 |
| | 99·20 | 100·74 |

The troilite amounted to 5·50 per cent. and the nickel-iron to 5·93 per cent., which had the composition:—

Iron = 90·64; Nickel = 8·35; and Cobalt = 0·73 = 99·72.

The mineral constituents are easily distinguished by the eye, and consist of:—

| | |
|---|---|
| Olivine minerals | 50·00 |
| Bronzite and pyroxenic minerals | 30·00 |
| Nickel-iron | 6·00 |
| Troilite | 5·50 |
| Chrome-iron | 0·52 |

In recording the three interesting falls at Rochester, Warrenton and Cynthiana, Dr. L. Smith draws attention to the remarkable fact that during a period of eighteen years there have been twelve falls of meteorites in the United States, of which specimens have been collected. Eight of these falls, with over one thousand kilogrammes of matter, have occurred over the prairie regions of the West, not far from his home; and the extreme limit of these falls is within a region not exceeding one-eighth of the surface of the United States, east of the Rocky Mountains. The population of this area is not much above the average of that country. The four other falls in the United States during the same period were attended with the descent of less than two kilogrammes.

### 1877, March 16th, 8 p.m.—Uitenhage, Cape of Good Hope, South Africa.[1]

A magnificent fireball, such as few would ever see in a lifetime, made its appearance in the East, "coming out of the eastern horizon" at Uitenhage, "and travelling slowly across the firmament in an oblique direction to the westward, when it burst, sending forth streams of fire, as if from a hundred rockets, and then was heard a low rumbling noise as of thunder in the distance. The meteor

[1] *The Times*, London, May 21, 1877.

appeared to be nearly if not quite as large as the full moon, but not round, more of an oblong shape, and while travelling through the air it very much resembled a large turpentine ball. It gave forth a bright bluish light, which lit up the whole sky, and you could distinguish everything around you for miles as plainly as in the daytime." Native Hottentots and Kaffirs, the account adds, were so terrified that they sought refuge in the nearest houses, and the apparition of the fireball was regarded by them as a warning of approaching famine, drought, or some other calamity. None of them had ever seen a meteor of anything like the size or half so brilliant as the present one. The oxen in the waggons stopped on the road and could not for some time be got to start again, others turned round, snapped off the disselbooms of the waggons, and bolted for some distance into the bush. The consternation was general in the country round Uitenhage. The illumination lasted nearly a minute, and the light was such that it dazzled the eyes of all who saw it. The events recorded took place on a beautiful starlight evening.

### 1877, May 17th, 7 a.m.—Hungen, between Steinheim and Borsdorf Provinz, Oberhessen.[1]

An eye-witness of the fall of one of these meteorites states that, as he was passing through a wood, on his way from Steinheim to Borsdorf, he heard a noise as of thunder, although the sky was cloudless, followed by a humming, hissing, whistling sound, such as would be caused by a number of stones rapidly rushing among the trees. One stone struck a pine tree close by him, severed a branch about the thickness of the finger, and fell at his feet. It was some time before he could convince himself that the object before him was not alive, but when he at last ventured to raise it from the ground he found it was cold.

Buchner visited the locality five months later and found a second stone, weighing 26 grammes. The first must have weighed more than 86 grammes, and a portion of it weighing 73·26 grammes has been deposited in the mineralogical collection of the University of Giessen. It has an irregularly triangular and flattened form, and less than one quarter of the stone has apparently been removed. It should be stated here that Buchner learned from several who were able to bear witness to the occurrence, that the sound attending the descent of the meteorites proceeded in a direction from N.W. to S.E. The freshly fallen leaves of mid-October rendered hopeless further search for the other stones which must have fallen.

The crust of the meteorite is dull black and thin, and exhibits here and there granules of nickel-iron. The fractured surface displays a grey, occasionally brownish, matrix, which is traversed by a very thin but very conspicuous brilliant black band of material; it runs obliquely to the flattened side of this stone, and is also found in the smaller mass, picked up five months later, which evidently never formed part of a larger meteorite. On another part of the fractured surface of the larger stone, a second black line, parallel to the first, but less brilliant, is to be seen. Abundant particles of nickel-iron and troilite are met with; and the crust appears to consist, to the extent of one-half, of the metallic alloy. Examination under the microscope shows the ground mass to be colourless and transparent, and to be fissured in every direction. It appears to consist of olivine. Some olivine spherules are quite conspicuous, surrounded either by the black material or nickel-iron; other chondra have a banded or radiate structure, like those observed by Tschermak in the aërolites of Shergotty or Gopalpur, and appear to be bronzite; and lastly, there are spherules of a homogeneous grey translucent substance, devoid of or rarely traversed by fissures. Buchner states that the meteorite of Hungen, while a member of the most common class of meteorites, can easily be distinguished from those which fell at Agen, Girgenti, New Concord, Knyahinya, Krähenberg, Pultusk, and many others which he mentions.

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[1] O. Buchner and G. Tschermak, *Mineralogische Mittheilungen*, 1877, 313.

The smaller stone was presented to the Vienna Collection, and forms the subject of a few notes by Tschermak in an appendix to Buchner's paper. He describes its characters, which nearly approach those of the Pultusk meteorites. The black crust has the unusual thickness of 1·5 mm., and incloses particles of nickel-iron, granules of magnetic pyrites (troilite?), and even lustreless chondra, which may consist of chromite or picotite. The transparent minerals constituting the chief mass of the stone are of three kinds: 1. *Olivine*, recognized by its rectangular cleavage and few included minerals, and by its contributing but little to the chondritic character of the stone; 2. *Bronzite*, in granules and aggregated crystals, showing a prismatic cleavage, the latter being either barred or radiate, or contorted and forming the greater number of the chondra; and 3. *Diallage*, for such Tschermak believes to be a brown mineral, forming angular fragments, which are found not to be rhombic, and to resemble an augite. Chromite occurs in granules, and in larger crystals than are met with in other meteorites.

This interesting stone has not yet been analyzed.

### 1877, June.—Cronstadt, Orange River Free State, South Africa.

All that I have yet been able to gather respecting this occurrence is, that a shower of stones fell near Cronstadt in June, 1877, in a wooded district, so that few of them could be collected. One of them is preserved in the British Museum.

### 1877, October 13th, about 2 p.m.—Soko-Banja, N.E. of Alexinatz, Servia.[1] [Long. 20° 53′ E. of Greenwich; Lat. 43° 38′ N.]

Döll's paper, which appears in the "Transactions of the Austrian Geological Society," contains two descriptions of the fall of meteorites at Soko-Banja, drawn from two different sources. The first, taken from the Servian weekly literary journal "Javor," published at Neusatz, is written by an eye-witness of the occurrence, who states that the 13th October was fine, and the sky clear, and that about two in the afternoon a noise as of thunder was heard resembling batteries of cannon firing briskly. The sound was followed by a violent concussion of the air, and then a number of aerolites were strewn over the adjacent region. One, weighing 10 okas (22½ Austrian pounds), fell in front of a house in Soko-Banja, and was driven deep into the earth; a second, which touched the ground at Scherbanowaz, near the Rtanj Berg, weighed 30 okas (67½ Austrian pounds), and is the largest mass which was collected. The peasants at Rtanj state that one which fell in that locality was of the size of a sack of flour, and that by striking the rocky surface it was dashed to fragments. From the second and later report, provided by Ritter von Stefanowitsch, of an inquiry instituted by some scientific men from Belgrade, it appears that two explosions like salvoes of artillery were heard, accompanied by a brilliant display of light such as attends the bursting of shells. A dense black smoke was observed at a considerable altitude, which broke up into three columns, and gradually changed to a white smoke. The noise lasted for some time, and then the sound resembled the firing of musketry. The air appeared to be shaken. Soon after the explosion commenced a number of meteorites fell to the ground over an area a mile and a half in length and half a mile in breadth. The following masses have been collected:—

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[1] E. Döll, *Verhandl. der K.K. Geolog. Reichsanstalt*, 1877, No. 16, 283. S. M. Losanitch, *Berichte der deutschen chemischen Gesellschaft*, 1878, xi. 96.

1. One, weighing 23 okas, fell in the village of Scherbanowaz, and penetrated the soil to the depth of four feet. (This is the one mentioned in "Javor.")
2. One, weighing 15 okas, fell near the vineyard at Soko-Banja, and reached a depth of three feet. This appears not to be the mass referred to in "Javor."
3. Two stones found at Blandija.
4. A fragment, weighing 2 okas, was found at Prevalač.
5. A meteorite of small size fell at Gradič (Prevalač and Gradič are hamlets, west of and close to Soko-Banja).
6. A number of pieces of various sizes fell at Dugopolje, and several very small stones are reported to have fallen on the Djeviza Planina.

One fragment, 2 okas in weight, fell on a pear tree, and then descended to the ground; a man who was under the tree took it in his hands, and received the impression that the mass was still warm.

The meteorites were sent to the Natural History Museum at Belgrade. Döll's paper contains two little maps indicating the area over which the stones were strewn. He describes a small specimen which came into his possession: the matrix is bluish grey and compact, inclosing spherules which vary in size from that of a millet-seed to that of a hare-shot, and which project from the fractured surface. But little nickel-iron or magnetic pyrites (troilite?) could be seen. He noticed patches of a brown colour, which he considers characteristic of this meteorite.

Losanitch, in his communication to the Berlin Chemical Society, which appeared subsequently, states that an interval of 25 seconds elapsed between the appearance of the meteor and the first explosion, which was followed by *two* others. The explosion occurred a an altitude of 7000 mètres. The path of the meteor made an angl of 220° 50′ with the magnetic meridian, and followed a course fro N.E. to S.W., with a very rapid descent. The track of the meteo has been calculated by Kleritj, and the details are to be found i "Glasnik," the journal of a Servian learned society. He make the entire weight of the stones, whole and in fragments, to weig 80 kilog.

All the meteorites are coated with a black rough vitreous crus 0·5 mm. in thickness, exhibiting numerous depressions. The interio consists of spherules of various sizes, some brown, some yellow cemented together by an ash-grey material, and presents the appearance of a trachytic lava. In polished sections, prepared for microscopic examination, nickel-iron in granules, hackly fragments an filiform particles, is to be recognized. The specific gravity of th meteorite is 3·502. The meteorite consists of:—

| | I. | II. |
|---|---|---|
| Nickel-iron... | 3·8 | 3·7 |
| Silicates | 96·2 | 96·3 |
| | 100·0 | 100·0 |

and a little iron sulphide. A fragment of the nickel-iron, which wa separated from all adhering silicate, possessed the composition:—

| | |
|---|---|
| Iron... | = 78·13 |
| Nickel | = 21·70 |
| Copper | = 0·17 |
| | 100·00 |

This is a high per-centage of nickel; the ratio of the metals is—Fe : Ni as 4 : 1. The iron sulphide was found to be the monosulphide, and to contain 63·84 per cent. of iron; theory require iron=63·64 per cent. Analyses of the complete meteoric rock containing the metallic alloy and iron sulphide, but freed from al trace of crust, were made—(1) by treating it with hydrochloric aci and caustic potash, which removed constituents amounting in thre cases to 60·50 per cent., 61·44 per cent., and 61·79 per cent.; an (2) by determining the ingredients of the portions (I.) acted upo by, and (II.) withstanding these reagents. They are as follow:—

| | I. | II. |
|---|---|---|
| Silicic acid | 32·24 | 56·66 |
| Iron protoxide | 28·41 | 23·55 |
| Manganese oxide | 0·20 | 0·003 |
| Magnesia | 30·53 | 20·84 |
| Soda | 0·43 | — |
| Potash | 0·09 | — |
| Iron | 0·70 | — |
| Nickel | 0·17 | — |
| Iron monosulphide = 6·78 { Fe | = 4·31 | — |
| S | = 2·47 | — |
| Chromite | — | 0·11 |
| Phosphorus | — | trace |
| | 99·55 | 101·63 |

Neither alumina nor lime appears to be present in this meteorite, and augitic and felspathic constituents are consequently absent. The oxygen present in the two silicates amounts to—

| | | I. | | II. |
|---|---|---|---|---|
| Silicic acid ... ... ... | | 17·19 ... ... ... ... | | 30·22 |
| Iron protoxide ... | 6·31 | =18·52 ... | 5·23 | ... = 14·56 |
| Magnesia ... ... | 12·21 | | 9·33 | |

The soluble portion, therefore, is an olivine, having approximately the composition represented by the formula $2(\frac{2}{3}\ MgO,\ \frac{1}{3}\ FeO),\ SiO_2$; and the insoluble part a bronzite of the form $(\frac{2}{3}\ MgO,\ \frac{1}{3}\ FeO),\ SiO_2$; the ratio of iron oxide to magnesia being the same in both silicates.

*(To be continued in our next Number.)*

## V.—ON THE CLASSIFICATION OF THE EUROPEAN ROCKS KNOWN AS PERMIAN AND TRIAS.

By the Rev. A. IRVING, B.Sc., B.A., F.G.S.;
Senior Science Master of Wellington College.

*(Continued from page* 164.)

(*c*) In the Midland Counties the rocks mapped as Permian are considered on all sides, if Permian at all, to belong to the Lower or Rothliegende series; we need not therefore stop to discuss them at any great length here. The chief authorities are Mr. Howell[1] and the late Prof. Jukes.[2] In Warwickshire the case is a simple one: there is, according to Mr. Howell, a *general unconformity* of the rocks called Permian with the Triassic strata which lie above them. In the Staffordshire area the case is somewhat different. After a careful perusal of Mr. Jukes's Memoir, I fail to find that his survey of the district enabled him to furnish any *direct* evidence of the unconformity between the Permians and the Trias, in the existence of which he expresses his belief in the text. It seems that the unconformity in this case is purely hypothetical. He conceives what would have taken place if extensive denudation had intervened in that area between the deposition of the Permian and Trias; but the *facts* mentioned by him may be equally well explained by *conformable overlap* of the Permians by the Trias, *unless the Permian strata were themselves conformable to the Carboniferous series*: this is shown clearly not to be the case. It would seem that the author was himself only half-convinced by the arguments he had put forward, for in the reduced section (No. 7), at the end of the Memoir, the Triassic strata are represented as lying *conformably* upon the Permian.

(*d*) A very interesting paper, which seems to me an important contribution to the science, has lately appeared. The author of it is Mr. D. C. Davies, F.G.S.[3] In this paper he has collaborated a large number of facts gleaned from actual sections in which the rocks known as "Upper Permian" occur. The paper is worthy of the careful perusal of every one who takes an interest in the question we are engaged in discussing. Space does not permit me to quote from it so fully as I could wish: but Mr. Davies's general conclusion may be given in his own words. After pointing out that the St. Bee's Sandstone is the undoubted equivalent of the so-called "Upper Permian" of the north-eastern area, which Sedgwick seems to have regarded as "having more in common with the strata above than with those below," he says, "The more complete the sections are which we obtain (of these beds and the Bunter above them), the less does the supposed break and unconformity become" (p. 24).

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[1] *Geology of the Warwickshire Coal-field,* by H. H. Howell, a "Survey" Memoir.

[2] Memoir on the *South Staffordshire Coal-field,* by J. B. Jukes, M.A., F.R.S.

[3] *Vide* Q. J. G. S. vol. xxxiii. *On the Relation of the Upper Carboniferous Strata of Shropshire and Derbyshire to the Rocks usually classed as Permian.*

In the face of all that has been now said, we must fail, as completely as the German geologists appear to have failed, to be convinced that there is any place to be found in the classification of the British rocks for an "Upper Permian," and the myth of a "Palæozoic Trias" vanishes from the serious side of the science.[1]

We must now turn our attention for a brief space to the *downward extension of the Permian or Dyassic system.* The first thing we note here (which I do not recollect having seen pointed out before) is the remarkable parallelism between the English and German Permian series in their southerly extension. Every one knows that the upper members (the Magnesian Limestone and its associated marls) of the northern counties are wanting in the Midlands south of the Trent Valley. Just so in Germany, as we proceed south, the Zechstein formation vanishes. The Dyassic order, as it appears in Thüringen, on the south of the Harz, and in Saxony, can be traced along the northern side of the Riesengebirge into Silesia, along the northern slope of the Lausitzer Range, and in the vicinity of Görlitz; and the wide distribution of the system is a fact in favour of the adoption of the *Dyas* as the normal representative of the system as it occurs in Europe. Southward it is no longer so well marked. In Bohemia it is represented by the lower formation only, the Rothliegende; but here red limestone strata containing *Palæoniscus Vratislaviensis*, Ag., and shales with *Xenacanthus Decheni*, Beyr., and *Acanthodes gracilis*, Beyr., intervene between the mechanical deposits. In South Germany the lower formation of the Dyas is widely distributed: it extends from Thüringerwald southwards, though extensively overlain by later formations, along the south-western slopes of the Fichtelgebirge and the Böhmerwald into Bavaria. One of the largest territories occupied by this formation extends south-west from Hunsrück, where it overlies the productive Coal-measures. It contains here feeble traces of Coal (as the corresponding deposits do in the South Staffordshire country), and consists of conglomerates, shales, and sandstones, as usual. The shales contain numerous nodules of clay-ironstone, with remains of *Amblypterus macropterus*, Bronn., and *Archegosaurus Decheni*, Goldf. The strata are often broken through by porphyries and melaphyres.[2]

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[1] Though still recognized in *Student's Elements* (Lyell), it is rejected by Sir A. Ramsay in his *Manual of British Geology; vide* p. 30.

[2] Credner, *El. d. Geol.* pp. 482, 483. See also pp. 473-477 of the same work for a good account of the eruptive rocks ('Gesteineruptionen') which intersect the Rothliegende of Germany.

The intrusion of crystalline igneous rocks among the lower members of the Permian series is repeated in many parts of Germany as well as in England; in the latter country it is found to be the case in the Vale of Eden and in the S. Staffordshire country. So great and widespread were the disturbances at this epoch that it becomes exceedingly difficult to recognize any general limit for the downward extension of the Permian or Dyas, and impossible to draw anything like a *horizontal line* which shall be equally true for the different portions of the European area. Among geologists a conviction has been gaining ground of late years that an error has been committed in drawing the base line too low in the geological series. A few references will suffice to show this.

1. Mr. W. T. Aveline, F.G.S., in a letter to the Editor of this MAGAZINE for 1877, p. 156, says: "The links that bound the Permian to the Carboniferous are now nearly all broken. The Lower Red Sandstone of Sedgwick, or Rothliegende of Murchison, lying below the Magnesian Limestone, with its coal-plants and even coal-beds, is now proved to be either Coal-measures or Millstone Grit, and the Permians of Staffordshire and Warwickshire are now said to be Upper Coal-measures, of a red colour." (In this generalization the writer would seem to overlook the great brecciated deposits of the Mid-West of England, which bear so striking an analogy to those of Thüringen and the Harz).

2. The same gentleman has recently re-surveyed the southern part of the Notts and Derbyshire Coal-field. The red sandstones and shales which lie conformably upon the Coal-measures, and were formerly included under the name of "Lower Red Sandstone" with the Permian series, have been definitely given up by him to the Coal-measure formation.[1] He gives good reasons for adopting the following tabulation of the Permian strata of this district:—

4. Red Marls and Sandstone.
3. Magnesian Limestone.
2. Shales (Marl Slate).
1. Breccia.

On this one remark is required by way of explanation. The Red Marls and Sandstone (4) are not the same as those mentioned in the previous part of this paper as having been grouped with the Lower Bunter. Those now referred to are subordinated to the Magnesian Limestone series; they underlie the other and more massive series in S. Notts unconformably; and they pass, when traced northwards, *under* the upper members of the Magnesian Limestone series. For a fuller description of the interesting sections in which the above sequence of deposits is exhibited the reader must be referred to the memoir itself, also to papers descriptive of them by Mr. E. Wilson, F.G.S.[2] The breccia (1) in the above table is well described by Mr. Wilson in the papers referred to, but is of a very different character from, and must not be confounded with, the great Permian breccias of the West of England, and of Thüringen. It forms here simply the basement-bed of the Magnesian Limestone and Marl Slate Series. There is a ***marked unconformity between it and the Coal-measures.***

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[1] *Vide Geology of the Country around Nottingham*, 2nd edition, 1880.

[2] *Vide* Quart. Journ. Geol. Soc. for November, 1876, *The Permians of the N.E. of England*; also paper by the same author on the *South Scarle Section*.

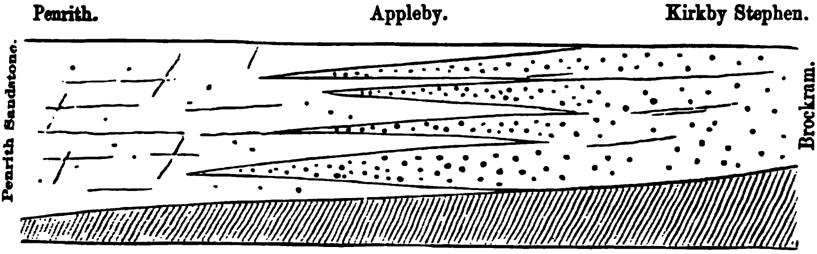
3. Mr. Wilson, who has for some years given great attention to the north-eastern area, has furnished good reasons, both in the papers just referred to, and in a further contribution to the ***Midland Naturalist*** (vol. iv.), for believing that in this area the "Rothliegende" is non-existent, and that the true base of the Permian series in the north-east of England is the Marl-slate with its underlying breccia. The so-called "Lower Red Sandstone," including the "Rotherham" and "Pontefract" Rocks, are regarded as true upper Coal-measures, as they have been for years past by the mining engineers of the district. Sanction to this view is given in the new edition of the Survey Map. It appears, therefore, that in our north-eastern area the Dyas of Germany is represented by one, and that its uppermost, formation only; the Magnesian Limestone with its subordinated Marls and thin-bedded Sandstones representing the Zechstein, while the Marl Slate series may be taken as the equivalents of the Kupferschiefer, which over a large part of Germany forms, as is well known, the base of the Zechstein formation.

If now we turn our attention to the Carlisle Basin, we find things reversed or nearly so. Years ago the rocks of this area were well described by Prof. Harkness.[1] He described six different sections, in four of which the rocks classed as Permian in the paper referred to are shown to rest on Carboniferous strata; in the other two sections they rest immediately upon rocks of Silurian age. Intrusive igneous rocks break in upon these deposits, as before mentioned, and as they do upon the Rothliegende in Germany. There is no distinct Dyassic division of the series here, though it is in the upper portion that the dolomitic beds occur; but even these are quite subordinated to the sandstones and shales with which they are interstratified. The fossil evidence is not very powerful, and is derived mostly from plant-remains; but these, as determined by Mr. Etheridge and Prof. Heer, give a Dyassic aspect to the group. Petrographically the series reminds one of the Lower formation of the Dyas, as it occurs in Bohemia on the south side of the Riesengebirge, in which feeble limestone deposits occur. In both cases the calcareous deposits are subordinated to those sedimentary deposits which are referable in their origin to mechanical agencies. It is in their petrographical character that these members of the same great system found in these widely distant areas would seem to bear the closest resemblance to one another. The enormous development of the breccias and sandstones of the Eden Valley and the vicinity reminds us of the gigantic proportions which similar deposits attain in Thüringerwald. In Annandale and some parts of Dumfriesshire and in the Eden Valley the breccias form the base of the series; but in the Valley of the Nith, on the west of Penrith, and in the section from "Great Ormside to Roman Fell," the base is made up of massively-bedded

[1] *Vide* Q.J.G.S. vol. xviii.

sandstones, which in one place attain the thickness of 2000, and in another the enormous thickness of 5000 feet (Harkness, *loc. supra cit.*).

Later and more detailed examination of this district by the officers of H. M. Geological Survey has shown that the main masses of the "Penrith Sandstone," whose great dimensions have just been mentioned, are upon the whole homotaxial with the principal brecciated masses known as the "Brockram"; so that the relation of these two chief members of the series, as they pass horizontally into one another, may be roughly represented by the following diagram, for which I am indebted to the kindness and courtesy of J. H. Goodchild, Esq., of the Geological Survey:—



Older Palæozoic Rocks (highly inclined).

These few facts presented by our north-western area must make us hesitate before we pronounce the strata which occur there to be "coloured Upper Coal-measures," or even "stained Carboniferous"; indeed, if any weight at all is to be allowed to a comparison of them with the facts presented in the Rothliegende of Germany, we can hardly do so, without classifying that great formation of the Continent also with the Carboniferous. Until we are prepared to do this, we must, it seems to me, from the evidence before us, admit that there is to be found in the Eden Valley and the adjoining country a true equivalent of the lower Dyassic formation of the Continent. These remarks apply of course only to the strata which have been mentioned; the Upper Sandstone series known as the "St. Bee's Sandstone" is excluded, for reasons already given. With this limitation the Permians of the Carlisle Basin will bear comparison upon the whole with the Rothliegende of Germany in several places, and especially in those parts where it is not succeeded by the Zechstein formation. I go further, and make bold to say that they bear comparison with the great Permian series of Russia (at least with the lower portion of that series), where, in a completely undisturbed area extending from Moscow to the Ural Mountains and north to the shores of the Arctic Ocean, the interbedded calcareous and dolomitic deposits, with their contained fossils, show what were the prevalent marine conditions in an area free from the direct influence of disturbing agencies, during a time when large portions of the German and British areas were thrown into tumultuous confusion.

(*To be concluded in our next Number.*)

# VI.—Traces of a Great Post-Glacial Flood.

## II. Evidence of the Loams and Brick-earths.

By H. H. Howorth, F.S.A.

THE best test of the difficulty of an inquiry is the number of theories which its solution has evolved. If we test the subject-matter of the present communication in this way, we shall be assured that, second only perhaps to the Loess, which has occupied us previously, it may claim pre-eminence for the difficulty of the problems which surround it. We only venture upon a tentative solution. Such a solution is in effect the only one which is available in science at all; for to-morrow's fiercer light is certain to throw out of perspective some of to-day's most cherished convictions; and finality is outside the pale of all living and fertile inquiry.

In our examination of the Loess we saw reason to conclude that it is very largely an accidental feature in surface geology. That so far as we can make out, it is largely due to the outpouring of quantities of volcanic mud, which swept over and mingled with the disintegrated beds which previously occupied the same area, at the time when the great cataclysm occurred, which forms such a clear barrier between Palæolithic man and his companions and those who came after.

If we therefore eliminate this accidental and transitory feature from our view, and realize the state of things before the Loess was poured out, we shall find, as we believe, that Europe, north of the Balkans and the Alps, may be divided into two well-marked zones: the northern one characterized by surface deposits consisting of Drift and the various boulder formations; and the southern by the absence of these boulder formations, and the presence of a great mantle of loam with associated gravels and sands. This loam is not found in Northern Europe, and marks a belt or zone which was once, as I believe, continuous from the Volga to the Atlantic. It occupies a large area in Southern Russia south of the Chernozem, and is known to the Russian geologists, as the same deposit is known to the French, as Diluvium. Mr. Belt tells us that in 1875, while detained at Wolochisk, in the province of Volhynia, near the Russian frontier, he found in the clay that had been thrown out of a well shells of *Succinea oblonga* and *Pupa muscorum,* which are very characteristic shells of the French loamy deposits. This clay caps the high plateau which forms the steppes of Southern Russia, and may, he says, be traced for hundreds of miles. He further adds, "On my return from a visit to Southern Russia during the present year (*i.e.* 1876), I determined to examine this clay, which is 'the Diluvium' of the Russian geologists, nearer to the mountains, and for that purpose stayed twelve hours at Podwolochisk in Galicia. I was greatly gratified by finding Loess shells (*i.e.* the very shells that are found in the French Diluvium) in abundance." — Quarterly Journal of Science, vol. xiv. pp. 74–5.

The areas occupied by Diluvium in Southern Russia and in France are now separated by the Loess. Before the outpouring of the latter, I believe that it was perfectly continuous from one area to the other. Where we can trace its junction with the Loess distinctly, we find that the latter has overlapped it, as we should in fact expect, if it were poured out over it, and it seems in every way very probable that Central Europe was once covered with the same mantle of loam that is found in France and Spain on the one hand, and the Russian steppes on the other, which was buried under or mingled with the Lower Loess when it was poured out. Traces of this sophistication are not hard to find. Thus Mr. Belt has remarked the continuity of the Loess and the so-called Diluvium in Austria; while Sir Charles Lyell says, speaking of the deposits of the valley of the Neckar, near Tubingen, generally claimed as Loess, "I found the fluviatile loam or brick-earth, inclosing the usual *Helices* and *Succineæ* together with the bones of the Mammoth, very distinct in colour and composition from ordinary Rhenish Loess" (Antiquity of Man, p. 380). [illegible]

This paper will be limited to the consideration of the zone of loamy deposits, and in it we shall have nothing to say of the Drift deposits, or those marked by boulders and erratics, but we must limit ourselves still further.

In Northern France the mantle of loam, as M. d'Archiac has shown by numerous examples; in South Britain, as is familiar enough to those who have studied the surface deposits of Kent and Sussex. in the case of the sophisticated loam that has mingled with the Loess in Central Europe and also in Russia, the loam overlies and is spread over beds of gravel and sand. The succession has been very much obscured in many places by denudation; but where we can examine it in an area that has not been much altered subsequently, this is generally the result. The gravels and sands which underlie the loamy strata form no part of our present subject. They are often classed and treated together with the loam, and this is natural, since there can be small doubt about their being contemporaneous; but it is convenient to treat them separately, and we shall in the present paper limit ourselves entirely to the loamy deposits.

These loamy deposits are known in a large part of France and Belgium as *Diluvium*, *Limon de Hesbaye*, *Limon des plateaux*, *terre à briques*, etc., and on our side of the Channel as Brick-earth. They vary somewhat in character. In the case of the Diluvium, the loam is mingled with sharp-edged flints, while these are largely absent from the *limon* and the brick-earths; but there can be no doubt that the view generally held that all these loamy deposits are on one horizon, and belong to one epoch, is well founded. They are all marked by the presence of the same land shells, the bones of the Mammoth and his companions, and, more important, by the more specialized works of primitive man, and their difference of texture can be easily explained. The first problem that has to be solved is, what is the origin of these loams? and the next, how did they come to be distributed as we now find them? In regard to their origin, the evidence is very much what it is in the case of the Loess. The absence of marine or fluviatile debris, the presence of flints with sharp edges showing they have not been waterworn, the presence in large numbers of intact land shells which are essentially fragile, the similar presence of remains of land animals, and of the works of man, all point in one direction only, and preclude the notion that these loams are either marine, lacustrine, or fluviatile. In regard to their texture, the evidence points the same way, and the following sentence of Mr. Belt, arguing against their fluviatile origin, seems to contain a just conclusion; he says, "The brick clay that overlies the gravel is considered by Professor Prestwich to be inundation mud. We have silty deposits now forming, or lately formed, on the low flats adjoining the Thames: they consist of dark blue clay, with remains of vegetation and land and fresh-water shells. Sometimes peat beds occur. The brick clay, on the other hand, is a homogeneous unstratified brown clay, without any organic remains."—Quart. Journal of Science, vol. viii. N.S. p. 346.

The view as to the origin of the loams, which seems supported by overwhelming evidence, is the one maintained by Professor Ramsay when Mr. Kingsmill's paper on the Loess was read before the Geological Society, namely, that the Brick-earths of our southern counties and the loams of Picardy are of subaerial origin. The beds have all the character of subaerial beds, and I have very little doubt that these loams represent the old land surface upon which the Mammoth and his companions lived. If it be not so, the burden of proof seems most certainly to lie upon those who maintain the contrary.

Having considered the origin of the loam, we may now turn to what more immediately concerns us, namely, its distribution. There is one remarkable feature about it to which attention has not been sufficiently attracted. The Diluvium in France and in Belgium and the Brick-earths in South Britain agree in this cardinal factor—that they are all separable into two well-marked forms: one stratum bearing all the marks of being largely in *situ* and undisturbed; and the second stratum being markedly disturbed.

In regard to the Diluvium of the French writers, the fact has long been familiar. One form of it is known as *diluvium gris*, while the other one is called *diluvium rouge*. For a long time a dispute prevailed among French writers as to whether the two are essentially distinct, or whether the *diluvium rouge* is not an altered and sophisticated layer of the grèy diluvium; its *rubification*, to introduce a French phrase of M. Vanden Broeck, being due to the infiltration of water containing acids. The best opinion now, and the one generally held, is that, although there is a certain difference between the two strata, the pebbles in the *diluvium rouge* being more rolled than in the other, while there is a greater scarcity in it of those mammalian remains which characterize so richly the *diluvium gris*, that nevertheless there is a complete continuity between the two, and that they belong essentially to one horizon.

The *diluvium gris*, with its numerous remains of a land fauna and abundant land shells, represents the old land surface upon which the Mammoths lived, *in situ*, and largely undisturbed. It is found almost entirely in the valleys where subaerial are naturally developed on the largest scale, and where least disturbed, and not distributed over the high ground, wh deposits are naturally scarce, and where, when they oc generally postulate that they are not indigenous, but import

The *diluvium rouge*, on the other hand, is found, not only the *diluvium gris*, but also distributed independently of the and of the river-courses, and covering the higher ground plateaux where it often lies immediately on the subjacen In Picardy and Northern France, and in Belgium, we ha a complete parallel with this. We have in the valleys a turbed deposit called indifferently *diluvium gris* or *dilu vallées;* while superimposed upon it, and also stretching be limits far away over hill and dale, exactly like the *diluviu* we have the mantle of surface loam called *Limon de Limon des plateaux*, etc. M. d'Acy has recently written elaborate and learned essay on this deposit, entitled "Le Li Plateaux du Nord de la France." With the views he mai ingeniously, and with such a fund of evidence, I most co agree. He shows that this "Limon" is perfectly continu the *diluvium gris*, that it corresponds precisely with the *rouge*, and that its mode of distribution can only be expl a great inundation. I shall revert to his memoir presently. while, I would reaffirm what I have already urged, that th deposits of Central Europe, where we can examine them, two distinct forms of deposition. One, *in sitû*, known as *gris, diluvium des vallées*, etc., equivalent to the Brick-earth Thames Valley. The other, the *diluvium rouge, limon des* upland loam or trail, having all the appearance of being disturbed. I shall endeavour to show that the cause of this ance was the same whose traces we have met with in t parts of this inquiry, namely, a widespread inundation.

In regard to the stratum *in sitû*, I would confine mysel argument only, drawn from the discontinuous nature of this If there had not been some denuding agency at work on and wide scale since this stratum was deposited, we should a have found it still remaining in a continuous layer in the but this is not so. Nothing is more familiar than the character of the patches of Brick-earth which are found in *th* of South Britain. The same is the case with the *diluviun* France. These patches and local seams are the mere which has not been denuded. What possible cause was co to break up and disintegrate this once continuous mantle and to leave these *débris* of it still remaining? The Glaci had passed by long before. Besides, glaciers or ice in any sha have scooped out the whole of these soft deposits, if it ha over them and ground them and their contents to uniform be deposited elsewhere; but there is not a fragment o evidence, so far as we know, of glacial conditions having to this period. A great rush of waters would effectually wa large portions of the soft loams, and such a flood is what we in fact invoke. But let us turn to the upper stratum, and see what a consistent and overwhelming story it has to tell. As I have said, this upper layer in France and Belgium, where it is known as *diluvium rouge* and *Limon des plateaux*, is spread over the whole country from the bottoms of the valleys right over the plateaux, independent of the local drainage of the district. It is very widely distributed in France and Spain, and sometimes, like the Loess, is found in deposits of considerable thickness. It has been found overlying the sands of the Landes near Bordeaux, and also in the neighbourhood of Madrid, in Spain, and extending over the plateau of New Castile. It is found at heights varying from 40 mètres, near Paris, to 660 mètres near Madrid. Elsewhere it is also found at great heights. M. Tardy tells us he met with it in 1871 on the Col del' Eremo, on the colline of Turni, at a height of 600 feet. Afterwards he met with it on the high plateaux between le Puy and Meude, and between the latter village and Saint Flour, at points 800 mètres high. He tells us further that it contained pebbles with their edges rubbed. This widely-distributed deposit, occurring thus on high ground far beyond the reach of any possible fluviatile action, apart altogether from the river drainage of the country, can surely only be accounted for, like the similar occurrence of the Loess, by a huge diluvial flow of waters. There is no pretence for invoking marine action, for there are no marine remains, and the French geologists who have examined the problem have been compelled to accept this explanation. This view explains at once why we should find diluvium containing no lime spread over large districts where limestone is the prevailing rock, and where that element would undoubtedly have been markedly present if the deposit had been indigenous, and the product of disintegration of the subjacent strata by fluviatile or other action, and not transported bodily by a strong flood from another district. Such a flood accounts for the rolling of the pebbles occurring in the *diluvium rouge*. It accounts again for the marked absence of any but traces of the bones of the big mammals in it. On the higher ground their carcases would be swept along into the lower ground in the valleys, while the flood would make a clean sweep of them from the plateaux, and deposit them below as it deposited the larger boulders.

Let us now turn to the conclusions drawn from these facts by the continental geologists who have examined them so minutely on the spot. M. Belgrand, the well-known author of "La Seine aux ages ante-historiques," has written a great deal on the subject. In a notice of his scientific work inserted by M. Alexis Delain in the 8th volume of the 3rd series of the Bulletin of the French Geological Society, pages lxv–lxxix, there is condensed for us the result of his researches, which is very interesting in view of the controversy raised in these papers. He goes deliberately through a number of forcible reasons why the conditions can only be explained by the predicate of a huge diluvial movement, which he expressly styles "unique et violent." The passages are too long to quote, but they must be read by those who want to understand the real conditions of the problem, and who will find in them matter for deep reflection, and naturally, for their author was a very patient inquirer, who was equally skilled as a geologist and an engineer, and what he had to say on a subject he had studied so long is naturally of the greatest authority. The cumulative character of the proofs, the number of curious facts which are brought to bear, geological, palæontological, dynamical, and mechanical, all tending to one conclusion, is certainly very convincing.

M. Belgrand contributed a memoir to the Brussels Congress of Anthropology, which is more readily quoted. In this memoir he says: "Many other facts tend to prove that a great mass of waters has ploughed up the plains of the North of France and of Belgium. I do not mean to say that there did not exist depressions in these plains, but all bear the marks of a violent flood of water. . . . These diluvial currents were destructive and were consequently charged with a great quantity of earth. It was a veritable sea of mud which was moved. . . . The diluvial currents which modelled the valleys have passed over all the plains of the North of France and of Belgium, and when, in consequence of the lowering of the waters, the currents lost their force, they have let fall this double deposit; coarse at the base, and fine above. The slightly undulating plateaux like those of Belgium, French Flanders, Picardy, the Pays de Caux, the Vescin both French and Norman, etc., etc., have preserved this muddy deposit universally of an ochreous colour, and it is known as red loam (*limon rouge*). Above it is the vegetable soil and the brick-earth of Belgium and the North of France. . . . The currents which excavated the valleys have thrown down on the convex surfaces of the corners or turning angles (*tournants*) the solid material excavated from the concave sides of the valleys or dragged by the water from the bottoms of the valleys, forming what are called terraces. Eventually, when the waters subsided, the double layer of sediment (*i.e.* the coarse and fine) was spread over these terraces. Sometimes it has penetrated into the body of the terraced deposits, sometimes it remains in two layers upon their surface (Comte Rendu, p. 133).

M. Tardy, in a communication to the French Geological Society, speaks as follows:—"From a comparison of the evidence furnished by the Cône de la Tiniere to M. Morlot, with that of the Saone, and with the results of the studies of M. Debray on the turbaries of Ancre, we must conclude that at the commencement of the Neolithic age the climate still felt the effects of the Quaternary period, *which came to an end by a great cataclysm.* In truth, the worked flints of Solutre (Palæolithic implements), which have been found in the marls in the valley of the Saone, and the first traces of the Neolithic age, there are about two mètres of deposits which indicate a lacuna, a hiatus, a complete absence of man, when they were deposited. At the base of this formation of two mètres thickness is a deposit which we can trace over all the plateaux. *This deposit of slight thickness has been left by a current sufficiently violent to turn* over all the boulders *which it encountered and sufficiently charged with mud to cover them with a coating of a red clayey character.* . . . This cataclysm evidently preceded the Neolithic civilization, and succeeded the Palæolithic one. As to its duration I can say nothing. Nevertheless, its violence, and the small deposit it left behind, would suggest that it was only of short duration" (Tardy, Classification de l'epoque quaternaire, Bull. Soc. Géol. de France, 3rd ser. vol. vi. pp. 401. 402).

Again we are told the *diluvium rouge* at such places as Bresse, where it can be easily distinguished, and where it occupies the summits of the plateaux, could only be the product of the action of a mass of water covering the whole plateau at a period posterior to the Quaternary formation, and anterior to the Neolithic and modern deposits (*id.* vol. vii. p. 507).

M. d'Archiac, speaking of the deposit we are discussing, as it occurs in the department of the Aisne, says, "It appears to be the result of a considerable inundation coming from the south-east, and which has enveloped with a vast mantle the valley of the Rhine, a part of Rhenish Prussia, Holland, Belgium, and the North of France."—(Descr. géol. de l'Aisne, p. 57.) Again, speaking of the department of the Oise, he concludes that the layer of clay and sand (*diluvium gris*) of the valleys there is identical in origin with the layer covering the plateaux, and says their "difference merely marks two phases of the same phenomenon, and depends on the swiftness, depth, and direction of the waters at various points. Where the current was the deepest and swiftest, *i.e.* at the opening of the secondary valleys into the primary ones, the diluvium containing flints is thicker, the flints are more rounded, and, if the neighbouring heights are of Tertiary strata, there is found in it fragments of the rocks, shells, and sands, which form these deposits, mixed with flints from the chalk. The *alluvion ancienne* (*i.e.* the upper diluvium and *limon des plateaux* of other writers) is more sandy and fine, and the shells gradually diminish in numbers as its texture gets finer, and we get on to higher ground."—(Essai sur la top. géog. du dép. de l'Oise, p. 529.) All this surely points to the mantle having been distributed by a great flood of water. Again, the same author says, "These deposits are not stratified in the true sense of the word. They do not occur in regular layers, continuous and distinct, like the sediment formed in the sea or in lakes. The inequality of their density, the different levels at which they occur, their discontinuity, and the variability of their character, are all proofs *that they owe their origin to torrential waters,* irregular in their volume and their power of transporting materials, which have carried along with the debris of the surrounding rocks the bones of the mammals which formerly inhabited the district. These latter become rarer as we leave the bottoms of the valleys, and in the ancient alluvium one hardly finds any of them, and such as there are, are always somewhat altered. We may conclude that the first torrents which swept over the country swept into the valleys all they met with on the surface."—(Bull. de la Soc. Géologique, 1845, p. 336.)

M. Trutat, in speaking of these deposits, distinguishes them sharply, from any deposits going on at this moment; the latter are horizontal, and do not mantle the sides of the valleys; the former do so, and are spread over them independently of the irregularity of their surface (Du Terrain Quaternaire et de l'Ancienneté de l'Homme, dans le Nord de la France, p. 17).

(*To be concluded in our next Number.*)

## REVIEWS.

### AN OLD CHAPTER IN THE GEOLOGICAL RECORD WITH A NEW INTERPRETATION; OR ROCK METAMORPHISM (ESPECIALLY OF THE METHYLOSED KIND) AND ITS RESULTANT IMITATION OF ORGANISMS. WITH AN INTRODUCTION GIVING AN ANNOTATED HISTORY OF THE CONTROVERSY ON THE SO-CALLED "EOZOON CANADENSE," AND AN APPENDIX. BY PROFESSORS KING AND ROWNEY. pp. 183 (including introduction), with cuts, and 9 coloured plates. (Van Voorst, 1881.)

THE *first* portion of this work deals with the question of "Eozoon" and of simulation of organized structures generally. The *second* deals with the question of wholesale substitution in rock masses.

1. *Simulation of organized structures.*—The spirit of controversy, if kept within reasonable limits, is beneficial to the progress of science, as it serves to fix the attention of many who would otherwise feel but a languid interest in questions involving much technical knowledge, and therefore beyond the detailed criticism of geologists, the majority of whom must plead ignorance to anything beyond an elementary knowledge of foraminiferal structure. As regards the disputants themselves, it is probable that the arguments on either side make but little impression on them: their views have been for the most part well "set" at an early period, and are only hardened as it were by every stage in the discussion.

The great "Eozoon" controversy has now been waged for well-nigh twenty years, and we are happy to say that the principals are still as vigorous as ever. Messrs. Dawson, Carpenter, and Sterry Hunt on one side, Messrs. King and Rowney on the other. The biologists favourable to "Eozoon" had an important auxiliary in Sterry Hunt, whose diagenetic doctrines with reference to the Archæan rocks came in very opportunely. Moreover, such eminent mineralogists and petrographers as Sorby and David Forbes are reported to have altogether disowned "Eozoon" as a mineral, whilst Bonney, in the discussion after his paper on the Lizard Serpentine, avowed his belief in the organic nature of "Eozoon." Hence it cannot be said that Drs. Dawson and Carpenter have received no support from mineralogists, though these latter have not perhaps given any very active assistance excepting in the case of Sterry Hunt.

In point of fact, some ten or twelve years ago the case for "Eozoon" seemed to have been concluded in the affirmative as admitted by Warington Smyth. It was accepted as satisfactory by nearly all the leading geologists, such as Lyell, Logan, Ramsay, etc., etc. The latter "had been struck long ago by the organic appearance of the structure now regarded as *Eozoon*. He had also felt a difficulty in accounting for the existence of large masses of limestone, except by the operation of organisms living in the sea, in which such deposits had been formed. He could not imagine the sea-water so overcharged with calcareous matter as spontaneously to deposit limestone."[1] Thus cherished by the most eminent students of the protozoa, accepted by the chief geological surveyors, and not doubted by many of the best known mineralogists and petrographers, it is no wonder that Eozoonism was triumphant at the Geological Society, and that Messrs. King and Rowney could but obtain the publication of an abstract of their second paper written in opposition to the then prevailing ideas (1868).

It is a somewhat singular circumstance that hardly any French author—if we may judge from the "introduction"—has interested himself in the question of "Eozoon," whilst the Germans,[2] on the contrary, have paid great attention to it, and for a long time were strong believers in its organic origin. The objections of Zittel and the defection of Möbius in later years have caused many people both in England and Germany to look upon the "creature of the dawn" as possibly a kind of Archæan *Bathybius* in close genetic connexion with its modern representative. The case of Möbius is a very strong one. With every wish to believe he was unable to do so. "My task," says he, "was to examine Eozoon from a biological point of view. I commenced it with the expectation of finding that I should succeed in establishing its organic origin beyond all doubt, but facts led me to the contrary. When I first saw the beautiful stem-systems in Prof. Carpenter's sections, I became at once a partizan of the view of Professors Dawson and Carpenter; but the more good sections and isolated stems I examined, the more doubtful became to my mind the organic origin of Eozoon, until at last the most magnificent 'canal-systems' taken altogether and closely compared with foraminiferal sections preached to me nothing but the inorganic character of Eozoon over and over again."—(*Nature*, July 24, 1879.) The authors are far from being satisfied with Möbius, and declare that his foraminiferal arguments are little more than an amplification of points advanced by Mr. J. H. Carter and themselves.

In concluding this short abstract of the history of the controversy, it should be mentioned that experts in "Eozoon"-structure have acquired appetite by eating, since some of them have been pleased to claim that graphic granite, for instance, might be regarded as a metamorphic form of an ancient organic structure. We are less surprised at the eccentricities of Hahn and Reinsch after this.

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[1] This is of course totally opposed to Sterry Hunt's "precipitation" views.

[2] It would seem that the idea of tracing organized structure in rock sections has recently become quite a mania with some Germans. This peculiarity has culminated in Hahn's "Urzelle," and above all in his "Die Meteorite," where 32 quarto plates are devoted to photographs of sections of meteorites, which are supposed to show structure like that of corals, crinoids, etc. In many of the photos there is an appearance which is evidently due to the effects produced by the section of some orthorhombic mineral—probably enstatite. In the last table of plates there is a photo which certainly is very foraminiferal, but returning to the explanation of plates, we find, instead of a celestial nummulite or aerial Eozoon, the disappointing words "Nummulit von Kempten." Still more recently Herr P. F. Reinsch has published an elaborately illustrated work, "Microstructur der Steinkohle," where some of the plumose figures intended for organisms have a most suspicious resemblance to radiations of calcite or other mineral deposit.

The obvious question then presents itself. If "Eozoon" is not organic, what is it? This the authors undertake to answer, and those who wish to know must consult their numerous publications on the subject, and more especially the present one on Rock Metamorphism. To understand the authors' views it will be necessary to study their terminology, and more especially the meaning attached by them to the word *Ophite* (= Ophiolite, or Serpent Stone). After reading the table on page 2, most persons will agree with the authors that "Ophites are not ordinary rocks."

Having mastered the terminology, it will then be possible for the reader to follow the authors through the first twenty-one pages of the proper text, where they "dispose of all the serpentinous structures of '*Eozoon Canadense*' in strict conformity with the mutations of all the minerals composing them." In the first place they demonstrate that the typical "nummuline wall" is a pectinated form of chrysotile, due to a modification of that allomorph of serpentine, where the fibres of the mineral ultimately become separated aciculæ with calcareous interpolations. The "canal system, etc.," is rather more obscure in its origin. It is frequently due to the peculiarities of a layer of flocculite (a non-fibrous allomorph of serpentine), which, on undergoing some solvent or decreting process, is apt to be shaped into irregular configurations. So likewise the "chamber castes" of the acervuline variety are identical with the variously lobulated crystalloids characteristic of Tyree "marble" and similar rocks, due, as the authors believe, to decretion of the original silicate.

As regards the calcitic layer containing the "intermediate skeleton" in typical specimens of "Eozoon," the calcite composing this part is "plainly a replacement pseudomorph after serpentine." This explanation would account for the alleged cases of "chambers" and "canal system" preserved in calcite.

2. *Rock substitution, or methylosis.*—The term "methylosis" was first proposed by the authors in the Geol. Mag. (Vol. X. p. 19, 1873), and they claim that it has precedence of the "metasomatosis" of Von Lasaulx and Knop. Whichever of the two be ultimately adopted, it is evident that some term is required to express that sort of metamorphism which is accompanied by more or less change of substance. The "metamorphic" rocks—making use of the word in its conventional and more extended sense—may thus be divided into the *mineralized*, where the original substances have crystallized, and the *methylosed*, where the constituents have undergone various degrees of chemical replacement, in some cases amounting to entire change of substance.

It need hardly be said that the views of the authors are totally opposed to those of Sterry Hunt, as recently stated in the Geol. Mag. (1878, p. 466). Messrs. King and Rowney represent the very opposite swing of the chemico-geological pendulum, and belong to that school which Delesse in his latter days designated as *métamorphisme à l'outrance.* Perhaps the truth may ultimately be found to lie somewhere between the two schools. Without prejudice one may truly say that it seems only reasonable to predicate an intimate relation between the original composition of a mass of rock and its present composition. If the contrary should turn out to be the case on the very extensive scale claimed by the authors, we must conclude that many a chapter in the earth's history has been blurred beyond the hope of deciphering.

*Ophites.*—There are so many different views as to the origin of serpentines and serpentinous rocks that the whole question abounds with pitfalls and snares, which are made worse owing to the different values attached to names by the various authors. Perhaps we may regard the subject as a sort of triangular duel between (1) the advocates of original precipitation, (2) the advocates of the alteration of magnesian silicates, and (3) the advocates of indiscriminate substitution. As the authors are disposed to believe that almost any sort of replacement may occur, they see no difficulty in the original constitution of any kind of rock, and may cite Dr. Heddle as suggesting that the structure of the "serpentine of the hill of Towansieff would lead to the conclusion that gneiss was the original." This last is certainly an extreme case of the theory of indiscriminate substitution. Doubtless, however, the authors would be prepared to account for it, somewhat as follows: First the muscovite of the gneiss would be magnesiated into phlogopite; this again would be methylosed into talc, and thus we should have a sort of protogine. Now protogine, according to the definition at page 2, is already a "sub-silacid Ophite." In this way, since "serpentynite" belongs to the silacid section, a relationship between the two is at once set up. Any quartz or felspar that might be in the way would of course be got rid of by a further wave of the methylotic wand, and, presto! your gneiss is converted into serpentine.

Again, because a pseudomorph of serpentine after tremolite can be adduced from the St. Gothard, it is assumed that there can be no difficulty in understanding that a diorite should be methylosed into Ophite. That depends very much upon the precise meaning attached to the word "Ophite." If chlorargyllites, chlorite-schists, and protogines are to be included, the wideness of the definition makes any statement of the kind a pretty safe one. To the notion that hydration of magnesian minerals and sediments is one great cause of "serpentinization" most people would say, Agreed. But the nature of the resultant should bear some relation to the composition of the original, especially in the case of large rock masses. A rock, for instance, originally poor in alumina, would yield a resultant containing a large proportion of serpentinite (hydro-ferro-magnesian silicate). Some would restrict the term serpentine to such rocks, and would regard them as having been derived from masses where *peridote* (olivine) predominated. This is perhaps too stringent a view of the case, since it is not difficult to suppose that certain massive non-aluminous amphiboles and pyroxenes may have contributed to form the purer serpentines as well as to produce the ophicalcites, etc. Moreover, we may have a partial serpentinization of an olivine dolerite ("greehstone"), such as that of Clicker Tor, which yields very interesting specimens.

Thus it may be fairly admitted that Ophites are polygenetic, and that to a certain extent even serpentine is so, but we should be disposed to draw the line for the present, so as to exclude the granites and felsites, and to limit the process to the more basic class of rocks. As regards the case of ophitic silicates in fissures, though the magnesian constituent may be largely derived from the containing rocks yet it might well happen in some cases that the sources are in a great measure foreign; and this may also be the case where rocks have been very much fissured, as in the serpentinous limestones of Connemara quoted by Harkness (p. 42). Furthermore, there can be no doubt as to the general correctness of the authors' view that some Ophites were sediments, whilst others were igneous rocks originally, but it is probable that where any great development of Ophite obtains, such rocks were originally rich in magnesia.

The authors have paid considerable attention to the subject of peridote in connexion with Ophites; but if a statement, made at p. 40, is to be taken as an example of their methods of reasoning, a grave suspicion must attach to much of their work.

It is well known that Zirkel, Bonney, and others, regard the occurrence of pseudomorphs of serpentine after peridote and the frequent association of the two minerals as evidence that Ophite, or its essential component serpentine, has originated from peridote or from "peridolytes." On this the authors observe that it would be just as reasonable to assume that basalt, because it usually contains a large proportion of peridote, was generated out of masses of this mineral. In other words that, because the hydrous (ferro) magnesian silicate, serpentine, is said to have originated from the anhydrous (ferro) magnesian silicate, peridote, that this same peridote might equally generate a complex mineral-aggregate like basalt, largely made up of augite and triclinic felspars, and rich in alumina, lime, and soda *in addition to* the bases of peridote. Such are the results of indulging too freely in methylosis.

A considerable portion of chapter xi. is devoted to proving that peridote is largely a secondary product. From the position in which that mineral has occasionally been found, as in veins of calcite traversing talcose schist, this may sometimes be the case. Its occurrence in the granular limestones (hemithrenes) is also quoted as showing its secondary origin: but if the authors' view be correct, as to the silicates in these limestones being merely the decreted remnants of the original minerals replaced by carbonates, the occurrence of peridote in these rocks can hardly be quoted in proof of its secondary origin.

Admitting, however, that peridote, like augite and other anhydrous silicates, may sometimes be formed in the wet way, we must regard this as the exception rather than the rule. That peridote occurs as an *original constituent* both in Carboniferous and Tertiary basalts is a view held by Allport and nearly all petrographers, and the effort on the part of the authors to prove that it is to a very great extent a secondary product, pseudomorphous after augite, looks very much like an attempt to turn the tables on their adversaries. They are particularly careful, it should be observed, to exclude the "extra mundane" peridotes, seeing that, since no hydrous minerals have yet been found in meteorites, nor any certain trace of water, the supposition that meteoric peridote is a methylosed product would be a little too strong even for the Galway Professors.

*Granular Limestones, Dolomites,* etc.—So much space has been devoted to the previous subjects that but little can be said under the above headings. These chapters are by no means the least interesting in the work, and the intimate acquaintance with the Magnesian Limestone of Durham possessed by one of the authors lends additional value both to the matter in the text and the appendix. If the reader cannot at present accept the new interpretation in all cases as the one which seems the most satisfactory, the authors supply him with abundant material for reflection on topics, which by their very nature are so obscure and difficult as to invite the widest possible divergence of opinion. W. H. H.

## REPORTS AND PROCEEDINGS.

### Geological Society of London.

March 8, 1882.—J. W. Hulke, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "Additional Note on certain Inclusions in Granite." By J. Arthur Phillips, Esq., F.R.S., F.G.S.

The author referred to certain rounded inclusions in granite which were rich in mica. These he had described in his paper published in vol. xxxvi. of the "Quarterly Journal," and had considered to be contemporaneous segregations from the molten rock. He had, up to that time, not found a case where one of the larger crystals of felspar in a porphyritic granite occurred partly in the one, partly in the other. Of late he had seen several, one of which he described minutely, thus proving the correctness of his supposition.

2. "The Geology of Madeira." By J. S. Gardner, Esq., F.G.S.

Madeira consists almost wholly of sheets of basaltic lava of variable thickness interstratified with tuff scoria and red bole, cut by innumerable dykes. In the central part of the island is a horseshoe-shaped valley, more than 4 miles in diameter, its bed 2500 feet above the sea, its precipitous walls full 3000 feet high, rising here and there to yet greater elevations, and forming a central point in the mountain system of the island. This the author regards as the basal wreck of a volcanic mountain, blown into the air by an explosion of exceptional violence. Fragments of the slopes of scoriæ which once composed the inner shell remain on the peaks surrounding this amphitheatre. The dykes here are trachyte. The author describes a limestone exposed in one place beneath the basalts, and referred to the Upper Miocene, and a plant-bearing bed associated with them, containing fossils of species still living in the island, some of which have been wrongly referred to extinct forms. In conclusion the author remarked upon the almost infinite variability of the genus *Rubus* and the difficulty of distinguishing its species.

3. "On the Crag Shells of Aberdeenshire and the Gravel Beds containing them." By Thomas F. Jamieson, Esq., F.G.S.

The author, in 1860, described beds of sand and gravel on the coast of Aberdeenshire, containing numerous fragments of Crag shells. His subsequent studies have enabled him to throw much further light on these shells and their mode of occurrence. The deposits containing the shells are almost wholly confined to the districts of Slains and Cruden, and extend up to heights of 225 feet above the present sea-level. They generally consist of coarse gravel with large subangular stones up to 2½ feet in length, intermixed with sand and muddy materials; the whole form ridges, like eskers or moraines, though glacially striated blocks are rare in them. The author describes the coast-section in detail, and shows that the shell-bearing gravels rest on materials that appear to be formed by glacial action and are covered by the Red Clay, which he regards as having been formed during the period of great submergence. The few entire shells are filled with a calcareous matrix, and fragments of the same material are found scattered in the gravel and sand. This lends support to the conclusion adopted by the author that the sand and gravel have been accumulated by a glacier moving over pre-existent Crag deposits. Among the shells found, 21 could be specifically determined, and of these 67 per cent. occur in the Coralline Crag, 95 per cent. in the Red Crag, and 57 per cent. are living species. Only one species, *Tellina balthica*, occurring in the Aberdeenshire deposits, is not found in the English Crags.

4. "On the Red Clay of the Aberdeenshire Coast, and the Direction of Ice-movement in that Quarter." By T. F. Jamieson, Esq., F.G.S.

The author describes a red clay occurring in the eastern part of Aberdeenshire, which differs in many important respects from the ordinary grey Boulder-clay of the district. Its contents appear to show that it has not been derived from the Jurassic and granitic rocks of Aberdeenshire, but from masses of Old Red Sandstone, now perhaps removed by denudation. Only few and imperfect molluscan remains, with bones of fish, aquatic birds, and seals have been found in this red clay. He regards it as having been formed during a period of great submergence which followed the period of maximum glaciation. He finds at Cove proof of a remarkable change in direction of the flow of the glacial ice. Additional proofs of the submergence are found in the old beaches with shells, extending to heights of from 380 to 470, and even up to 560 feet above the sea-level. The Mollusca occurring in these raised beaches are all of living species, but now occur in arctic seas. He differs from Mr. J. Geikie, who regards these deposits as of post-Glacial age and of estuarine character. He concludes by describing in detail the remarkable section exhibited in the Bay of Nigg.

# CORRESPONDENCE.

## THE MILLSTONE GRIT AT VOBSTER.

Sir,—The amount of disturbance and confusion existing in the Coal-measures immediately north of the Mendip Hills has long been a subject which has greatly exercised the scientific imagination of geologists. Any fact that can throw light upon the question, or that serves to support one theory or the other in explanation of the inversions of strata in the Nettlebridge Valley, is worthy of record. One such fact it is in my power to lay before your readers in connexion with the Vobster inversion. That coal has been worked beneath this mass of limestone it is scarcely necessary for me here to assert. Mr. McMurtrie has satisfactorily established that fact in a paper read before the Bath Field Club in the year 1874, and published in the third vol. of the "Proceedings." But how did this mass come here? In a paper contributed to your Magazine for 1871, p. 150, with the legitimate horror entertained by a member of H.M.G.S. against cataclysmic action, Mr. Horace B. Woodward attempts to account for this abnormal position of the limestone by a compound reversed fault and anticlinal theory, and an ingenious "Diagram Section" is given to illustrate his view. In his dissent from the theory which would account for this position by a folding over of the main ridge, he states, that a serious difficulty presents itself in the absence of the Millstone Grit which ought to be found in its true position between the Mountain Limestone and the Coal-measures proper, had their folding over to the north really occurred. Now it gives me much pleasure to state that the discovery of these hitherto missing beds in the position required must remove this "serious difficulty." During a recent visit with Mr. McMurtrie and others to Vobster, we found that the quarry men, under Mr. Batey's superintendence, in driving a tunnel through the south face of the quarry in a northernly direction were then actually in the Millstone Grit beds, which were severely trying the temper of their tools. These beds dipped at an angle of about 46° S., and were found beneath shales and limestone dipping from 46° to 55° in the same direction and thoroughly conformable. Thus another proof has been added in support of the view that these beds have been turned completely topsy-turvy; in other words, the upthrow-fault theory of the earlier writers having already been proved to have no real existence, and the chief objection which seems to have hindered Mr. Woodward, a geologist well acquainted with our Mendip complications, from accepting the generally accepted view of a folding over of the beds, having now been met; what remains, but to accept the alternative that these beds, originally horizontal, have been squeezed together, thrown up, and finally folded over from the main ridge, by some process which it would take a long glimpse down the corridors of time to fully comprehend and unravel.

11, Cavendish Crescent, Bath, H. H. Winwood.

## CHARLES DARWIN. M.A., F.R.S.

BORN FEBRUARY 12, 1809; DIED APRIL 19, 1882.

DEATH, with tender hand, has taken away our most celebrated Naturalist, Charles Darwin; one of whom it is not too much to assert that he has made a greater impression on the minds of men of science throughout the world, than any of his contemporaries. His publications have had the effect of exciting numberless persons to make observations for themselves, and thus unconsciously to become naturalists; whilst, both directly, and indirectly, our store of scientific knowledge has been enlarged a thousandfold. He was born at Shrewsbury on Feb. 12, 1809, his father being Dr. Robert Waring Darwin, F.R.S., physician of that town. His grandfather was the celebrated Dr. Erasmus Darwin, F.R.S., the poetical and scientific physician of Lichfield. His mother was a daughter of Josiah Wedgwood, the modern founder of the English pottery manufacture. Charles Darwin was educated at Shrewsbury Grammar School under Dr. Butler, thence he went to the University of Edinburgh in 1825, remained there two years, and next entered Christ's College, Cambridge, where he graduated B.A. in 1832, and M.A. in 1837. His hereditary aptitude for the study of natural science was early perceived, and the Rev. Prof. Henslow recommended him to Captain Fitzroy and the Lords of the Admiralty, in 1831, as Naturalist to accompany the second Surveying Expedition of H.M.S. *Beagle* in the Southern Seas. The first expedition, that of the *Adventure* and *Beagle* (1826-30), had explored the coasts of Patagonia; the *Beagle*, which sailed again December 27, 1831, and returned to England October 22, 1836, made a scientific circumnavigation of the globe. Mr. Darwin served without salary, and partly paid his own expenses, on condition that he should have the entire disposal of his zoological, botanical, and geological collections. On returning to England, he published a "Journal of Researches into the Geology and Natural History" of the various countries he had visited. This originally appeared with a general account of the voyage by Captain Fitzroy, but was afterwards published separately. Since that time Mr. Darwin has resided at Down, near Farnborough, Kent. In addition to numerous papers on various scientific subjects, Mr. Darwin edited the "Zoology of the Voyage of the *Beagle*," and wrote three separate volumes on geology—viz. "The Structure and Distribution of Coral Reefs," 1842, second edition 1874; "Geological Observations on Volcanic Islands," 1844; and "Geological Observations on South America," 1846. The most important of Mr. Darwin's subsequent works are a "Monograph of the Family Cirripedia," published by the Ray Society in 1851-3, and on the Fossil Species of the same group, by the Palæontographical Society. But by far the most widely-known contribution from Mr. Darwin's pen was his famous "Origin of Species by means of Natural Selection," published in 1859, which has gone through several editions at home, and has been translated into French, German, Italian, Spanish, and other European languages. No other book ever caused a more profound sensation, and probably no book was ever received with such extreme manifestations of scientific enthusiasm and scientific incredulity.

Briefly summarized, the propositions submitted by its author are as follows:—More organisms perish than survive. No two individuals are exactly alike. Individual peculiarities are transmissible. Those individuals whose peculiarities bring them into close adaptation with their surroundings survive and transmit them to their offspring. The survival of the fittest thus tends to maintain an equilibrium between organisms and their surroundings. The environment of every group of organisms is steadily changing. Every group of organisms must therefore change in average character under penalty of extinction. A change set up in one part of an organism necessitates changes in another part. These changes are complicated by the law, that structures are nourished in proportion to their use, and the changes thus set up must alter the character of any group of organisms. These propositions being granted, Darwin simply asks us to believe that, since the appearance of life, time enough has elapsed to produce all the variation of species now seen. His subsequent works have had for their object the supplying the data on which he founded his conclusions. A treatise on "The Fertilisation of Orchids," published in 1862, was followed by "Domesticated Animals and Cultivated Plants; or the Principles of Variation, Inheritance, Reversion, Crossing, Interbreeding, and Selection, under Domestication," in 1867. In 1871 he published the "Descent of Man and Selection in Relation to Sex," two volumes, a new edition of which was published in 1874, in one volume, with large additions. Also, "The Expression of the Emotions in Man and Animals," published in 1873; "Insectivorous Plants and Climbing Plants," in 1875; "The Effects of Cross and Self Fertilisation in the Animal Kingdom," in 1876; "Different Forms of Flowers in Plants of the same Species," in 1877; the "Movement of Plants," in 1880, a continuation of his investigations on the movement and habits of climbing plants; and in October last, "The Formation of Vegetable Mould through the Action of Worms."

As a matter of course, Charles Darwin was a member of most of the leading scientific societies, both at home and abroad. He had also obtained the Royal and Copley Medals from the Royal Society, and the Wollaston Palladium Medal from the Geological Society, and had lately received many high distinctions, including the Prussian Order "Pour le Mérite" in 1871, degrees from the Dutch University of Leyden in 1875, and from that of Cambridge (LL.D.) in 1877, the corresponding membership of the French Academy in 1875, and also the corresponding membership of the Academy of Vienna.

In 1831 he married his cousin, Miss Emma Wedgwood, who survives him; he also leaves a family of five sons and two daughters.[1]

## DR. JOHN LYCETT.

We regret to record the death of this excellent geologist, and hope to give some notice of his work next month.

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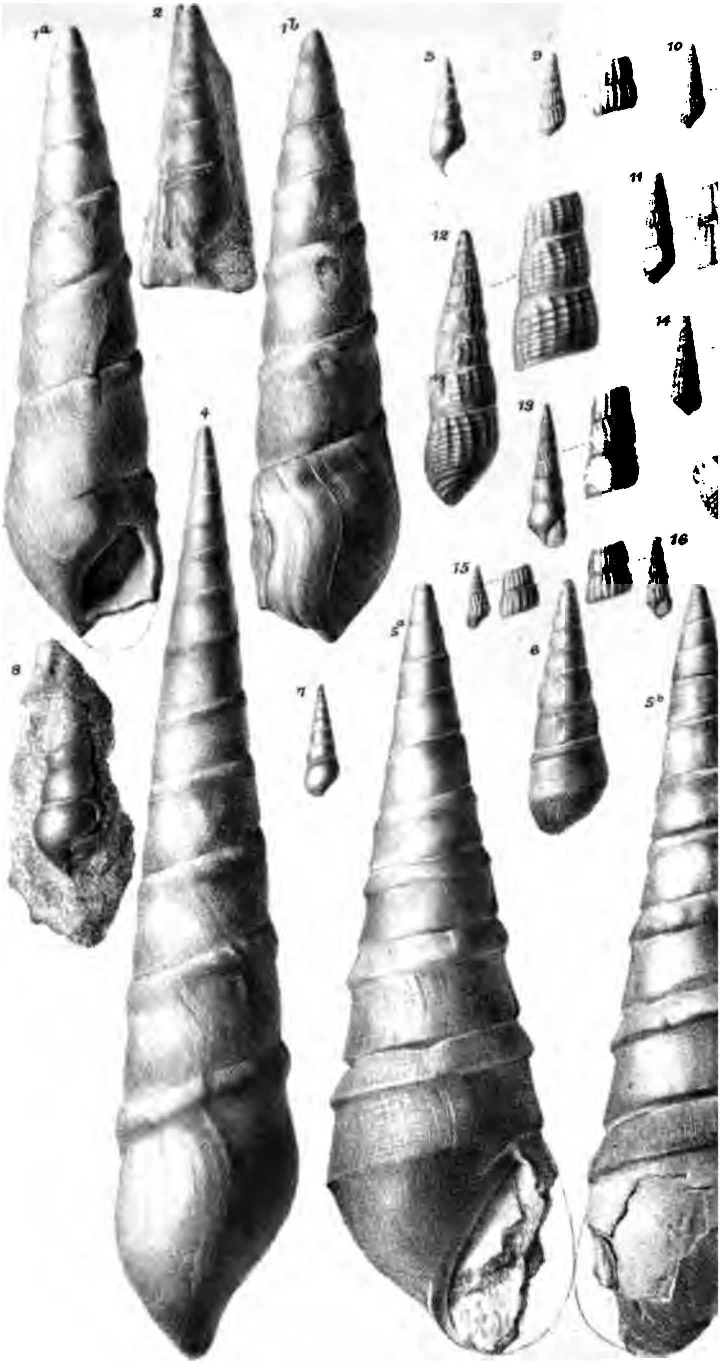
[1] Most of the facts here stated appeared in the *Morning Post*, April 21, 1882.



Oxfordian and Lower Oolite Gasteropoda, Yor

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G. M. Woodward del et lith.

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. IX.

No. VI.—JUNE, 1882.

## ORIGINAL ARTICLES.

## I.—Contributions to the Palæontology of the Yorkshire Oolites.

By Wilfrid H. Hudleston, M.A., F.G.S.;
President Geologists' Association.

(*Continued from page* 205.)

(PLATE VI.)

### Chemnitzia, etc.

I MUST refer to Memoir No. 1—Corallian Gasteropoda—for remarks with respect to the so-called Chemnitzias. The curious group, of which "*Terebra vetusta*," Phil., may be regarded as the type, is also very doubtfully placed under *Chemnitzia*.

### 11.—Chemnitzia lineata, Sowerby, 1821. Plate VI. Figs. 1*a*, 1*b*, 2, 3.

1821. *Melania lineata*, Sow., Min. Conch. pl. 218, fig. 1.
1829 & 1835. *Melania lineata*, Sow., Phillips, G. Y. p. 129.
1842. ? *Melania procera*, Deslongchamps, Mem. Soc. Linn. Norm. vol. vii. p. 223, pl. 12, figs. 5 and 6.
1852. ? *Chemnitzia procera*, D'Orb., T. J. p. 41, pl. 239, figs. 2, 3 (under the name of *turris*).
1852. Non *Chem. lineata*, D'Orb., T. J. p. 43, pl. 239, figs. 4 and 5.
1875. *Chemnitzia lineata*, Sow., Phillips, G. Y. p. 257.

*Bibliography, etc.*—The complete synonymy of this very common, variable, and widely-spread "species" would be about the most hopeless task which any one could undertake to compile. This *Chemnitzia* is very abundant in the I. O. of Normandy, where, out of the very pretty pictures given by Deslongchamps, perhaps two leading forms might be selected, of which we may regard this as representing one, and *Melania coarctata* the other. In a fit of despair, MM. Hébert and Deslongchamps, whilst criticizing the attempts of D'Orbigny to set matters to right, declare that it is almost impossible to distinguish between "les *Ch. heddingtonensis, procera, coarctata* et *normanniana*: il vaudrait peut-être mieux les réunir toutes en une seule espèce, qui serait alors commune a l'oolithe inférieure, à la grande oolithe, et à l'Oxfordien."[1] Mr. Tawney considers that there are two species or at least good varieties at Dundry, and he is disposed to separate *Ch. lineata*, Sow., from *Ch. procera*, Desl.[2] I cannot think that the question of punctate structure is anything more than one of *status* (condition of preservation). All these smooth Chemnitzias are striato-punctate under certain conditions, whilst there are other conditions where the feature is not shown. It so happens that the specimen figured by Sowerby shows this peculiarity in a very slight degree. Most of the specimens from the Dogger show it, but not all.

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[1] Héb. et Desl. *op. cit.* p. 34.

[2] Dundry Gasteropoda.

In the other two zones of the Inferior Oolite in Yorkshire this structure is not noticeable either in the species of *Chemnitzia*, or, as far as my observations go, in the species of *Natica*, whose representatives show it so strongly in the lower horizon.

*Description* (Figures 1*a* and 1*b*). — Specimen from the Dogger (zone 1) Peak (Blue Wyke). Leckenby Collection.

| | |
|---|---|
| Length (restored) | 95 mm. |
| Width | 20 ,, |
| Length of body-whorl to entire shell | 28 : 100. |
| Spiral angle | 14°–15°. |

The upper portion of the spire is so indifferently preserved that the above measurements must be received with reservation. The three anterior whorls are in tolerable condition, with the suture well marked. The upper portion of these whorls shows a flattish belt, very feebly developed, in front of which is a slight constriction and then again a slight fulness, after which the whorl is again constricted to meet the next suture. Rugose and wavy lines of growth, accentuated by conditions of fossilization, are conspicuous. A fine striato-punctate structure is discernible, chiefly on the penultimate whorl.

Aperture oval, and rather small. This effect is increased by thickening of the outer lip through adherence of matrix.

(Fig. 2).—Another specimen from the Dogger. My Collection.

| | |
|---|---|
| Spiral angle | 15°. |

This serves to show the early stage, where the belt is but feebly developed, yet increases in importance with each succeeding whorl, the slight constriction of the whorl increasing *pari passû*. Sutures clean cut out, and angular. Surface smooth, no striato-punctate structure visible.

(Fig. 3).—Another specimen from the Dogger. Bean Collection, British Museum. This serves to show the youngest stage. The apical whorls are flat and devoid of any varix, and the suture close. I think that this is the form called "*Terebra melanioides*" by Bean.

*Relations and Distribution.*—If we are to make a distinction according to whether or no punctate structure is visible, Figs. 2 and 3 will represent *Ch. procera*, Desl. It is a point on which opinions will perhaps continue to be divided for the present.

It should be borne in mind that all these large Chemnitzias commence with a very flat whorl. The apical whorls of *Chem. Heddingtonensis* are probably the *Chem. melanioides* of Phillips.

*Chem. lineata-procera* is well represented in the Dogger and Millepore; nor do I think there is any *real* difference in the variety next to be described from the Scarborough Limestone.

### 11*b*.—CHEMNITZIA LINEATA-PROCERA, var. SCARBURGENSIS, Morris and Lycett, 1850. Plate VI. Fig. 4.

1850. *Chemnitzia? Scarburgensis*, M and L., Gt. Ool. Moll. p. 115, pl. xv. fig. 8.
1875. *Chem. Scarburgensis*, L. and M., Phillips, G. Y. 3rd edition, p. 257.

*Bibliography, etc.*—This "species" was described from a flattened cast, which is now in the Bean Collection at the British Museum. The authors' figure conveys a false impression of the real shape, and causes an appearance of a larger spiral angle than is warranted. If the cast were restored to its proper shape, the angle would not be materially larger than in the specimen described below, which is unusually fine and in good preservation.

*Description.*—Specimen from the Scarborough Limestone (zone 3). Leckenby Collection.

| | |
|---|---|
| Length (restored) | 138 mm. |
| Width | 24 ,, |
| Length of body-whorl to entire shell | 29 : 100. |
| Spiral angle | 13°. |

Shell conical, elongate. Spire consists of about 15 whorls. These increase in height regularly by one-third of a turn each time. The apical whorls are flat, but presently the belt near the suture begins to develope, and the median constriction to show. As the whorls attain a more mature stage, the constriction is most marked in the upper third; anteriorly the whorl swells again before curving inwards to meet the suture. In the last two whorls the belt is very prominent and rounded (possibly from attrition or otherwise). Certain rugose markings in connexion with lines of growth are noticeable, principally on the penultimate whorl. No punctate structure visible.

The specimen, being involved in matrix, has been drawn in an oblique position.

*Relations and Distribution.*—I cannot see any real differences, other than those due to fossilization, between this specimen and specimens from the Millepore Bed and Dogger. This is a very acicular form, having perhaps rather a smaller spiral angle than the average of specimens.[1]

The common Bajocian *Chemnitzia* of the Yorkshire Beds is distinguished by this small spiral angle from another and stouter form, which really is perhaps entitled to be regarded as a distinct species.

### 12.—CHEMNITZIA ? COARCTATA, Deslongchamps, 1842.

1835. *Melania Heddingtonensis*, Sow., Phillips, G. Y. pp. 123 and 129.
1842. *Melania coarctata*, Desl., Mem. Soc. Linn. Norm. vol. vii. p. 226, pl. xii. figs. 11 and 12.
*Melania Heddingtonensis*, (pars) Deslong., *ibid.* p. 225.

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[1] One of the evils of having too many names for slight varietal differences is illustrated in the tables of fossils given by Dr. Wright in his admirable and instructive paper on the Inferior Oolite of the South of England and of Yorkshire (Q. J. G. S. 1859); *e.g.* from the *Humphresianus* zone of Somerset the author quotes *Chem. lineata*, Sow. (p. 36), from the Grey Limestone (zone 3) of Yorkshire *Chem. Scarburgensis*, Lyc. and Mor. (p. 30), and from the Oolite Marl of Cheltenham *Chem. procera*, Deslong. (p. 13). What, I wonder, is the real biological distinction between these three? As a museum label for the cast of a Bajocian *Chemnitzia* in a grey matrix, probably *Ch. Scarburgensis* may continue to do duty.

There is a form of *Chemnitzia* which occurs in the Dogger, and perhaps in the Scarborough Limestone, having a larger spiral angle, and being altogether of a stouter build than *Ch. lineata.* This perhaps was noticed in the earlier editions of Phillips as *Melania Heddingtonensis*, Sow., but in the last edition (1875) that species is not quoted from the Lower Oolites—*Ch. Scarburgensis* apparently taking its place.

Now of course *Ch. Scarburgensis* may be made to cover anything, being simply the flattened cast of a large *Chemnitzia*, belonging in all probability to the *lineata-procera* group.

Nothing more can be done at present than simply to point out the fact of the occurrence of this stouter form, which, as far as I can judge, is less turrited than Normandy specimens of *Chem. coarctata.* No specimen sufficiently good for determination from the Yorkshire beds has ever come into my hands.

13.—CHEMNITZIA VITTATA, Phillips, 1829. Pl. VI. Figs. *5a*, *5b*, and 6.

1829 & 1835. *Melania vittata*, Phil., G. Y. p. 116 (ed. 1835), pl. vii. fig. 15.
1853. *Chemnitzia vittata*, Phil., Lycett, Suppl. p. 14, pl. 31, fig. 10.
1875. *Chemnitzia vittata*, Phil., G. Y. 3rd ed. p. 257.

*Bibliography, etc.*—This species was adequately described and figured for the first time by Lycett, who alludes to the fact that D'Orbigny (Prod. vol. i. p. 295) supposed *Nerinæa suprajurensis*, D'Archiac, might be the same. Oppel (Jura Formation, p. 479) in his synonymy accepts D'Orbigny's supposition. Lycett does not favour the view.

*Description* (Figs. *5a*, *5b*).—Specimen from the Cornbrash (zone 4), Scarborough. Leckenby Collection.

| | |
|---|---|
| Length (complete) | 112 mm. |
| Width | 32 ,, |
| Length of body-whorl to entire shell | 30·5 : 100. |
| Spiral angle | 22°. |

Shell conical, elongate, sub-turrited. The complete spire is composed of about ten or twelve whorls, which increase under a regular angle; and are flat and without protuberance in the early stage. The apical portion of the spire is, consequently, a smooth elongate cone, unbroken save by the suture, which is clean cut, rather narrow, and moderately oblique. By degrees a belt, which rapidly assumes the character of a varix, is formed towards the posterior margin of the widening whorl. This becomes a prominent feature, since it falls away very steeply towards the slightly excavated median area of the whorl, which swells towards a second but less pronounced varix on the anterior margin. Edges of the anterior whorls bevilled off towards the strongly marked suture. In the body-whorl the space between the two varices is still more hollowed out.

The aperture is oval and tolerably wide, with fair evidence of thickening posteriorly where the callus is very prominent. Inner lip almost detached anteriorly.

Being in the usual wax-like condition of fossils from the Scarborough "Cornbrash," the specimen is favourable for showing the wavy lines of growth, and the peculiar granulated spiral lines, which, under certain circumstances, become a striato-punctate structure. This is especially noticeable in that portion of the penultimate shown in Fig. *5a.*

(Fig. 6).—Specimen from the Cornbrash. Leckenby Collection.

This serves to show the apical conditions before the varices attain to much importance.

*Relations and Distribution.*—If we regard the subject of these large Chemnitzias in anything like a philosophical and comprehensive spirit, we can hardly fail to give at least a partial assent to the sweeping suggestion of MM. Hébert and Deslongchamps already quoted. That *Chem. lineata-procera,* the typical Bajocian form, *Chem. vittata,* the typical Bathonian form (in Yorkshire), and *Chem. Heddingtonensis,* the typical Oxford-Corallian form,[1] are closely connected, it is impossible to deny. They occupy, in a certain sense, the relative positions of a number of generations as one sees them depicted in some ancestral gallery, where the family features, though recognizable, are modified; but where the costume of the period, like the mineral condition of the fossil, serves to emphasize and even to exaggerate such differences as may exist.

*Chem. vittata* chiefly differs from the other forms in the salience of its varices, and especially of the lower one, which is but faintly seen in other Jurassic Chemnitzias. Dr. Lycett[2] has pointed out how it differs from members of the *Ch. coarctata* group. This we can understand, as they are of different age. Yet *Ch. vittata* should have its representative in other Bathonian beds besides the Cornbrash of Yorkshire, though at present I am unable to say that the precise form has been quoted from any of the noted Bathonian localities, such as the Boulonnais (Rigaux and Sauvage), Langrune in Normandy (Deslongchamps), or our own beds of Great Oolite age, including of course the Cornbrash of the midland and southern counties.

### 14.—Chemnitzia Heddingtonensis, Sow. See "Corallian Gasteropoda."

Imperfect forms of *Chemnitzia* are found in the Lower Calcareous Grit, which may be referred to this "species."

### 15.—Eulima lævigata, Morris and Lycett, 1850. Plate VI. Figs. 7 and 8.

1850. *Eulima lævigata,* M. and L., Gt. Ool. Moll. p. 114, pl. xv. fig. 4.

*Bibliography, etc.*—The type is quoted from the "Great Oolite" near Scarborough. That is really our third zone, viz. the *Humphresianus*-zone of the Inferior Oolite. The figure is somewhat misleading. Lycett, in his Supplement (p. 13, pl. 31, fig. 3), figures a specimen from the Cornbrash, which he contrasts with *Eulima communis* from the real Great Oolite of Minchinhampton.

*Description* (Fig. 7).—Type refigured.—Specimen from the Scarborough Limestone (zone 3). Bean Collection, British Museum.

| | |
|---|---|
| Length | 15 mm. |
| Width | 5 ,, |
| Spiral angle | 22°. |

---

[1] See Corallian *Gasteropoda,* Geol. Mag. 1880, p. 393.

[2] op. cit.

Shell elongate, smooth, subulate. Whorls short, and rather convex, especially the anterior ones. Surface smooth. Suture fairly marked. Lines of growth faint. Aperture involved in matrix.

(Fig. 8).—Specimen from the Cornbrash (zone 4), Scarborough. Leckenby Collection.

The spire is much injured, but the three anterior whorls are in good preservation. These whorls are extremely round and full, with a deep suture which gives a strangulated appearance. The whorls are so extremely smooth that even the lines of growth can scarcely be detected.

*Relations and Distribution.*—Very little of a satisfactory nature can be made out of these supposed Eulimas in the Yorkshire beds. The Cornbrash specimen described above is, as far as the anterior whorls go, in an excellent state of preservation. The marked convexity, even roundness of the whorl, and the absence of any punctate structure, are distinguishing features. It does not seem to tally quite either with the description of *Eu. communis* or with the type of *Eu. lævigata* (Fig. 7). Rigaux and Sauvage quote both these species from the Cornbrash (Calc. à *Rhynch. Badensis*) of the Boulonnais. Found sparingly in zones 3, 4, and 5.

A specimen from the Chert bed of the Kelloway Rock was figured and described as "*Chem. lineata*" by Leckenby, Q. J. G. S., February, 1859. This was subsequently regarded by the author as a *Eulima*. The specimen is not in a satisfactory condition for specific determination. If the spiral lines are visible, the specimen is most probably the young stage of *Chemnitzia*.

### "CHEMNITZIA" VETUSTA group.

These fossils are more numerous and better preserved in the Inferior Oolite of the Anglo-Norman area than elsewhere, and would naturally attract the attention of authors. No palæontologist of the present day can read the introduction to the memoir "sur les Mélanies fossiles" by the elder Deslongchamps, written just forty years ago, without a tacit feeling of respect for the sagacity of that observer of former days. The difficulties he then felt are difficulties still. "Plusieurs (des Mélanies) sont de petite taille et se rapprochent par leur *facies*, de quelques-un des Cérites decrits dans le Memoire précédent, mais leur ouverture c'est plus décidément celle des Mélanies. Pour exprimer toute ma pensee, je crois qu'il y a des *passages* entre ces espèces anciennes."

The substitution of the genus *Chemnitzia* for the supposed *Melaniæ* of the Jurassic period increases the difficulty as regards the small costate forms now under consideration, which constitute a sort of debatable ground on the borders of the genus *Cerithium*. These remarks apply to a number of fossils, to which I would give the name *vetusta*-group, from their relationship to the original *Terebra vetusta*, Phil., which occurs in the Millepore Bed (zone 2) of Cloughton Wyke.[1] A remorseless lumper of varietal forms might indeed unite them all under one "species," to which the name *vetusta* would, in right of priority, attach.

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[1] See below, p. 248.

Besides the very great differences in appearance superinduced by the character of the matrix, there really does seem to have been considerable regional variation in a set of forms, which Deslongchamps, for the I. O. of Normandy, focussed under two headings, viz. *Melania undulata*, and *Melania scalariformis*. Some of these varieties may be noticed in the I. O. of Bradford Abbas, where very fine spathic fossils are to be had. The Dundry variety is referred by Mr. Tawney to *M. undulata*.[1] The group is perhaps more characteristic of the Lias[2] than of the Oolites, and it does not appear to ascend in its more typical form, above the Lower Oolites,[3] at least in Yorkshire. But in the 1st and 2nd zones of the Inferior Oolite on the coast there are certain forms which exhibit such constant variety as to render them worthy of some notice.

### 16.—"CHEMNITZIA" VETUSTA, Phillips, 1829. Plate VI. Figs. 9, 10, 11.

1829 and 1835. *Terebra vetusta*, Phil., G. Y. p. 123, pl. ix. fig. 27.
1840. Ibid. Ibid. Williamson, Trans. Geol. Soc., 2nd series, vol. v. p. 241.
1842. *Melania scalariformis* (pars) (? Deshayes), Deslongchamps, Mem. Soc. Linn. Norm. vol. vii. p. 218, pl. xi. figs. 63–66.
1844. *Cerithium flexuosum*, Münst., Goldfuss, t. 173, fig. 15.
1850. *Chemnitzia vetusta*, D'Orb. (Phil.), Prod. vol. i. p. 263.
1869. *Cerithium vetustum*, Williamson, Brauns, Mitl. Jura, p. 172.
1875. *Chemnitzia vetusta*, Phil., G. Y. 3rd edition, p. 257, pl. ix. fig. 27.

*Bibliography.*—Brauns further unites under this "species" *C. armatum*, Goldf., *C. echinatum*, Von Buch, *C. muricatum*, Quens. pars, ? *Mel. undulata*, Desl., *C. granulato-costatum*, Münst., and *muricato-costatum*, Münst., *C. granulato-costatum*, Quens. (Jura, pl. 65, fig. 22, and Foss. of Montreuil-Bellay, pl. 7, fig. 1), and *C. tortile*, Héb. & Desl.

Evidently this is a stable that requires a good deal of cleansing, but to refer all these to the Cloughton shell is, it seems to me, to act under a misapprehension, more especially as Brauns considers that the figures of Phillips, and of Morris and Lycett, do not represent the same species.

Certainly these figures present a different appearance, but at any rate we can have no difficulty as to the identification of Phillips's type, which the author says expressly comes from the "Oolite" of Cloughton Wyke. The exact bed is well known to all those who are acquainted with the palæontological stratigraphy of the district. It is a subcalcareous and ferruginous grit in the upper part of the Millepore Bed. In Phillips's figure the costæ are rather too close together, and too numerous. They are not decussated.

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[1] Dundry Gasteropoda, p. 11.

[2] Strong longitudinal ribs, straight or slightly curved, and but little decussated; an aperture, which, when one can see it, has a tendency to a slight channel in the front, but is otherwise Chemnitzoid; these features characterize the group of which several species are enumerated, and some new ones described by Tate and Blake in their Memoir on the Yorkshire Lias.

[3] Some fossils lately discovered by the Survey in beds of presumed Lower Oxfordian age in Lincolnshire (on the horizon of the Scarborough Kelloway Rock perhaps) appear to represent the group.

Briefly summarized, the propositions submitted by its author are as follows:—More organisms perish than survive. No two individuals are exactly alike. Individual peculiarities are transmissible. Those individuals whose peculiarities bring them into close adaptation with their surroundings survive and transmit them to their offspring. The survival of the fittest thus tends to maintain an equilibrium between organisms and their surroundings. The environment of every group of organisms is steadily changing. Every group of organisms must therefore change in average character under penalty of extinction. A change set up in one part of an organism necessitates changes in another part. These changes are complicated by the law, that structures are nourished in proportion to their use, and the changes thus set up must alter the character of any group of organisms. These propositions being granted, Darwin simply asks us to believe that, since the appearance of life, time enough has elapsed to produce all the variation of species now seen. His subsequent works have had for their object the supplying the data on which he founded his conclusions. A treatise on "The Fertilisation of Orchids," published in 1862, was followed by "Domesticated Animals and Cultivated Plants; or the Principles of Variation, Inheritance, Reversion, Crossing, Interbreeding, and Selection, under Domestication," in 1867. In 1871 he published the "Descent of Man and Selection in Relation to Sex," two volumes, a new edition of which was published in 1874, in one volume, with large additions. Also, "The Expression of the Emotions in Man and Animals," published in 1873; "Insectivorous Plants and Climbing Plants," in 1875; "The Effects of Cross and Self Fertilisation in the Animal Kingdom," in 1876; "Different Forms of Flowers in Plants of the same Species," in 1877; the "Movement of Plants," in 1880, a continuation of his investigations on the movement and habits of climbing plants; and in October last, "The Formation of Vegetable Mould through the Action of Worms."

As a matter of course, Charles Darwin was a member of most of the leading scientific societies, both at home and abroad. He had also obtained the Royal and Copley Medals from the Royal Society, and the Wollaston Palladium Medal from the Geological Society, and had lately received many high distinctions, including the Prussian Order "Pour le Mérite" in 1871, degrees from the Dutch University of Leyden in 1875, and from that of Cambridge (LL.D.) in 1877, the corresponding membership of the French Academy in 1875, and also the corresponding membership of the Academy of Vienna.

In 1831 he married his cousin, Miss Emma Wedgwood, who survives him; he also leaves a family of five sons and two daughters.[1]

## DR. JOHN LYCETT.

We regret to record the death of this excellent geologist, and hope to give some notice of his work next month.

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[1] Most of the facts here stated appeared in the *Morning Post*, April 21, 1882.

*Relations and Distribution.*—This form may be regarded as the one described and figured by Morris and Lycett from a specimen in the Scarborough Limestone. It probably represents one of the varieties of *Melania scalariformis* so characteristic of the Inferior Oolite of Normandy, and may possibly be, in part, *Cerithium muricato-costatum*, Münst.

It differs chiefly from the typical *C. vetusta* (Figs. 9 and 10) in the decussating nodes on the posterior margin of the whorls.

Fig. *A* represents the aperture of a variety of *Melania scalariformis* occurring in the Inferior Oolite of Bradford Abbas. The slight groove or canal at the anterior extremity is scarcely consistent with the notion of *Chemnitzia*. The Yorkshire specimens of the *vetusta*-group are not sufficiently well preserved to show for certain whether this critical feature exists or not.

20.—? CERITHIUM MURICATO-COSTATUM, Münster, 1844. Pl. VI. Fig. 17.

1844. *Cerithium muricato-costatum*, Münst., Goldfuss, t. 173, fig. 12.
1860. Cf. *C. tortile*, Héb. and Deslong. Foss. of Montl. Bellay, p. 39, pl. vi. fig. 1.

*Description.* — Specimen from the Millepore Bed (zone 2). Leckenby Collection.

| | |
|---|---|
| Length ..................................... | 13 mm. |
| Width ..................................... | 3 ,, |

Shell elongate, narrow, subturrited. Apical whorls imperfect. The six anterior whorls are in a good state of preservation, but the base is concealed in matrix. The longitudinal costæ are straight or very slightly curved, and deeply and regularly decussated, so that the sculpture on the ribs is highly granulated.

Other specimens from the same bed are somewhat less elongate, but with the same style of ornament.

*Relations and Distribution.*—This shell seems to occupy an intermediate position between *Ch. vetusta*, which has the rib wholly unornamented, and *Cerithium muricatum* (Dogger variety), where the longitudinal and spiral systems of ornament are almost of equal strength. It should be regarded, I have little doubt, as a *Cerithium*, but its relationship to the *vetusta* group, which many people also would relegate to *Cerithium*, induces me to place it here for the sake of comparison.

The most characteristic specimens are found in the Millepore Bed, but something very like it occurs on other horizons, even as high up as the Lower Calcareous Grit, where the form referred to *Cerithium Russiense*, D'Orb., is not very dissimilar. It may be fairly admitted that, where the ornamentation of the whorls is so modified by conditions of fossilization, accurate specific distinction becomes almost an impossibility.

## EXPLANATION OF PLATE VI.

FIG. 1. *Chemnitzia lineata*, Sow. (? = *Melania procera*, Deslong.). Dogger, Blue Wyke. Leckenby Collection. *a*. Front view; *b*. back view.

,, 2. *Ibid.* Specimen showing an earlier stage. Dogger, Blue Wyke. My Collection.

,, 3. *Ibid.* Specimen showing a still earlier stage. Dogger, Blue Wyke. Bean Collection, British Museum.

Fig. 4. *Chemnitzia lineata-procera*, var. *Scarburgensis*, Morris and Lycett. Scarborough Limestone. Leckenby Collection.
,, 5. *Chemnitzia vittata*, Phil. Cornbrash, Scarborough. Leckenby Collection. *a.* Front view; *b.* back view.
,, 6. *Ibid.* Specimen showing an earlier stage. Cornbrash, Scarborough. Leckenby Collection.
,, 7. *Eulima lævigata*, Morris and Lycett. (Type Refigured.) Scarborough Limestone. Bean Collection, British Museum.
,, 8. *Ibid.* Variety from the Cornbrash, Scarborough. Leckenby Collection.
,, 9. "*Chemnitzia*" *vetusta*, Phil. Millepore Bed, Cloughton Wyke. Leckenby Collection.
,, 10. *Ibid.* Specimen from same locality. Bean Collection, British Museum.
,, 11. *Ibid.* Specimen from the Dogger, Blue Wyke. Leckenby Collection.
,, 12. "*Chemnitzia*" *vetusta major.* Dogger, Blue Wyke. Leckenby Collection.
,, 13. "*Chemnitzia*" *vetusta*, var. *seminuda.* Dogger, Blue Wyke. Leckenby Collection.
,, 14. "*Chemnitzia*" *vetusta*, var. ? *scalariformis*, Deslong. Millepore Bed, Cloughton Wyke. Leckenby Collection.
,, 15 and 16. Varieties of the *vetusta*-group. 15 from Millepore Bed. 16 from Dogger (see p. 248).
,, *A.* Body-whorl of a variety of *Melania scalariformis*, from Bradford Abbas, to show the character of the aperture.
,, 17. Cf. *Cerithium muricato-costatum*, Münst. Millepore Bed. Leckenby Collection.

*(To be continued.)*

## II.—The Glacial Geology of Central Wales.

By Walter Keeping, M.A., F.G.S.;

Keeper of the York Museum.[1]

In Cardiganshire and the neighbouring counties of Central Wales there are abundant traces of the action of the great accumulations of ice and snow which covered all the mountains of Britain in the Glacial period. In the valleys lie thick sheets of Till and morainic formations, the hill-sides are rounded and polished by the friction of the moving ice, and erratic blocks are strewn in abundance over hill and valley throughout the district.

*Geology and Physical Features.*—The solid geology of the country has been already described by me elsewhere,[2] and it is only necessary here to mention that the whole country consists of monotonous repetitions of greywacke (hard argillaceous grit), hard shales, and imperfect slates, the latter forming a large area by itself in the central part.

The whole country is mountainous; the hills are rounded and bare, and the highest ground is usually a dreary level waste of wet and boggy ground, dotted with lakes and pools. The two most important physical features of the district are the great planes of marine denudation which limit the height of the hills, truncating their tops, so that a view from the summit shows a great plain, irregularly broken up by the river valleys. The lower plane rises gradually from 400—500 feet at the coast to 700 feet inland, and the higher plane starts abruptly at about 1100 or 1200 feet, and gradually slopes up to 1500, where it abuts against the highest island-like mass of Plynlimmon. From many points of view these two planes and their cliff-like line of separation are strikingly shown, for example, from the hills above Cwm Gwarchau, Machynlleth, and between Goginan and Cwm Symlog.

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[1] Read at the Meeting of the British Association, Section C, at York, 1881.

[2] Quart. Journ. Geol. Soc. 1881, p. 141.

The Drift formations range over both these planes reaching up to within 100 feet of the highest ground. They consist principally of ice-formed stony clay or Till, which may be overlain by stratified beds of loam, sand, and gravel, of later glacial age, these being covered in the river valleys by the more modern river gravels.

We may observe at once that over nearly the whole of this country the drifts consist entirely of local materials, and when any difference of character occurs in the general uniformity of the solid rock, we can usually see that the drifts have been formed from the degradation of the rocks within the present drainage areas. Exceptions to this rule are found only on the extreme N. and S. borders of the county (Cardiganshire).

*Glaciated Rock Surfaces.*—The various surface features usual in glaciated districts are well marked in this area, many of the hills showing well the flowing contours on their sides, and the valleys, such as Nant Myheran, exhibiting the broad U-shaped sections characteristic of old glacier courses. *Roches moutonnées*, with polished and striated faces, are still perfectly preserved, as fresh as if the old glacier had but just left them. Large erratics and perched blocks are abundant, and in places the crushing force of the ice has torn up the ground rock, and carried the fragments onwards in a broken stream at the base of the Till. Examples of the latter phenomenon are seen in the cliffs under the old castle at Aberystwyth, and the coast section four or five miles south of that town. In the latter place the solid rock is fractured and disturbed to a depth of five feet from the base of the stony clay.

The ice-polished rocky mounds known as *roches moutonnées* are particularly well preserved in the district, the polish and striation on the rocks being actually as perfect as those seen around modern glaciers. Good examples are exposed at the head of the Llyfnant valley, particularly one fine broad back at the base of the waterfall called Pistill y Llyn; other good examples will be found in the Claerwen valley, at Pont Faen, Machynlleth, on the side of Afon Tarenig, Plynlimmon, also on the banks of Llyn Fyrddyn Fawr, L. Glaslyn, and L. Bugeilyn, and half a mile west of Cwm Berwyn Farm.

*The Stony Clay or Till.*—A good section of the Till is exposed in the cliffs at Ffos las and Cwm Ceirw, south of Aberystwyth. The deposit consists of a matrix of amorphous stiff blue clay crowded with small angular grains and shaly fragments. This paste is thickly studded with rocks of all sizes, from mere fragments to large masses several tons in weight. Most of the stones are subangular and well striated, a few are rounded, and others are unworn and angular. Patches of angular blocks occur in several places, showing scarcely any traces of rounding or striation. All the rocks are of local origin. This deposit is so tough that it forms high overhanging cliffs, seventy or eighty feet high. Above the Till occur roughly stratified clay and sandy clay of pale yellowish colour, with waterworn pebbles and a few striated stones. In places this graduates into the underlying stony clay.

The main mass of this Cwm Ceirw drift is in an old hollow, apparently an old river bed with steep sides, in the centre of the existing valley, the western hill boundary having been destroyed by the encroachment of the sea since the Glacial period; for where the streamlet has cut back the Till at the north end, it is seen to abut against a nearly vertical wall of solid rock running in the line of the present valley.

Some remarkable features have been produced in these cliffs by the action of a number of small periodic streamlets which arise as springs a few feet from the surface. These have cut their way back into the Glacial clay, so as to form deep open gorges, with narrow, slit-like seaward openings, also fantastic ridges and pillars, in several cases leaving actual earth pillars, with capping stones, like the well-known examples in the Tyrol. It is a most extraordinary and striking example of streamlet and pluvial denudation.

Another excellent section is exposed in the railway cutting between Aberystwyth and Bow Street Stations, where the deposit is of the same general nature but more clayey; also the cliff sections of stiff stony Till opposite the village of Llanrwsted are deserving of notice.

In the interior of the country stony clays, similar to those already described, are of frequent and widespread occurrence in the valleys and along the sides of the hills, and they are particularly developed in the open parts of the valleys, where they form broad and thick sheets. Examples are seen in the valley below Llyn Llygad Rheidol and in the Teifi valley below the Teifi Pools. In the Rheidol valley near Aberystwyth this drift was found to be fifteen feet thick in a recent cutting, and it is probably much thicker in places.

The influence of projecting rocks and sheltered curves in determining the deposition and greater thickness of the stony clay is marked in many places, as in the railway cutting near Bow Street, and at Pen Craig, north of Llanilar, where a "tail" of glacial stony clay has been laid down on the lee side of the protecting knoll of rock.

*Moraines.*—The terminal and lateral moraines of Cardiganshire are not such well-marked and striking objects as many of those in Scotland and Snowdonia. Their structure and composition are also different, and, I should say, less typical; for the surrounding rocks being of a softer and more agillaceous character, the moraines are also of a clayey nature. They may be described generally as clayey masses, full of comminuted shale fragments and grit, studded more or less abundantly with angular and subangular stones. Long lines of such morainic matter occur along the south sides of Cwm Berwyn and in Cwm Ystwyth. The Cwm Ystwyth moraine is less clayey than usual, consisting of a mass of shale fragments and angular stones, like a rubbish-tip of small material, with numerous blocks of grit and slate of all sizes. The deposit has been deeply scored by a number of small freshets which course down the hill-sides in wet weather.

*Terminal Moraines.*—Various hummocky mounds and semicircular ridges seen in the upper parts of some of the valleys are clearly the remains of morainic matter heaped up at the end of the melting glaciers, *i.e. Terminal moraines.* In some cases they form banks at the foot of lakes, as in the Llyn Glaslyn, Llyn Gwyddior, and Llyn Llygad Rheidol, where they hold up the waters beyond the levels of their rock basins. Other examples are seen just below Diffwys; and in the side valleys at Blaen y Cwm, and under Craigddu in Cwm Ystwyth.

*Erratics.*—The erratic and perched blocks are distributed in an irregular and promiscuous manner, some areas being crowded with them, as over the country east of Llanfihangel and Cwm Ystwyth, where they are dotted like sheep over the hills, while in other places, *e.g.* around Llynodd Ieuan, we may walk for miles without seeing one. They are found at great heights, as in the high ground above Cwm Symlog towards Goginan, where fine groups occur at 1000 and 1200 feet levels. All are local rocks, namely, the Greywacke and Shaly Slates (with certain exceptions to be mentioned below), and but few are of great size. Fine examples occur around the lakes Llyn Eiddwen and Llyn Berwyn, and at Nant y maen, Tregaron. Some boulders of quartz east of Llanfihangel may have come from mineral veins, and a fine boulder of conglomerate on Gogerddan Hill, which contained a few fossils, has probably come from the Plynlimmon hills.[1]

These erratics are angular, and bear no marks of water- or ice-wearing upon them, and I regard them as having been for the most part launched off from the sides of the glaciers and left stranded upon the hill-sides as the ice gradually fell to lower levels.

*Boulders from beyond the present drainage areas.*—I have already stated that it is only at the northern and southern borders of Cardiganshire that any erratic blocks occur whose origin cannot be referred to the present valley systems. The best example is in the charming little Llyfnant Valley, south of Machynlleth, where large blocks of felsite occur, which can only have come from the mountains further north, in the Cader Idris or Aran Ranges. One of the blocks lying in the Llyfnant stream measures about 12×9×11 ft. These boulders show that the ice from the mountains of North Wales came down in such volume that even the broad Dyfi could not contain it, and it overflowed at the little pass south of Machynlleth and streamed down into the Llyfnant Valley. This is the only case I have met with of the invasion of Central Wales by the northern ice.

Erratics of felsite and highly altered rocks occur in the main valley south of Machynlleth, but these of course belong properly to the North Wales Valley system.

At the southern end of the county, around Cardigan, is a glacial clay of a different character, which is worked for brickmaking at the north end of the town. It is a stiff, unctuous clay, slightly gritty in the mouth, of a purplish and brownish blue colour, with a sprinkling of subangular, ice-scratched pebbles. Patches of more arenaceous and more stony Boulder-clay also occur in an irregular manner. The included pebbles are mostly slates, including some pale and some gritty slate, also greywacke, much Mountain Limestone, Old Red Sandstone, Coal-measure Sandstone, Felsites and Greenstones. This deposit appears to have been formed by a large glacier which had its origin in the Caermarthenshire hills of South Wales, where the Upper Palæozoic pebbles were obtained. Thence it streamed westwards, overriding the intervening watershed, and forcing its way down through the Teifi valley to the Irish Sea. Boulders of the same rocks, foreign to the district, occur also in the country further north towards Aberporth, up to a height of 700 feet.

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[1] See a paper on "Geology of Central Wales," Q. J. G. S. 1881, p. 158.

*Lakes.*—Small lakes and pools are of frequent occurrence in the high ground (on the higher marine plane) in Cardiganshire, usually in groups of two or more.

The accumulation of morainic matter at the bases of some of these lakes has already been mentioned, but all are in the main true rock basins, the morainic accumulations (at Llyn Llygad Rheidol, etc.,) adding nothing or very little to the depth of the basin. There is, I believe, no case of a simple moraine dammed lake in the county. Those examined by me proved to be nearly all shallow depressions from 7 to 32 feet deep,[1] irregular in form, several of them having islets in their midst.

An exception to this must now be noticed, namely, Llyn Llygad Rheidol, a sombre pool under the precipitous head of Plynlimmon, which is much deeper (60 feet) than the others. The position of this lake is highly favourable for ice erosion, and the section of its bed agrees better in shape with ice-worn hollows. It is indeed, in my opinion, a very good example of an ice-formed rock basin. The clayey terminal moraine at the foot of the lake acts as an additional dam for deepening the waters.[2]

In all the other cases there is no high ground near where a local glacier of any adequate size could have collected. Indeed, the general arrangement and directions of the lakes, the sections of their beds, their contours, and the features of the neighbouring land alike show that a glacial erosion theory is utterly inapplicable to the formation of these rock hollows, and we must refer to other causes for their origin. The neighbourhood of most of the lakes is remarkable for the frequent foldings of the rocks, and in one case (Llyn Fyrddyn Fawr) there is a fault, with slickensides well exposed near the water's edge. I look to earth movements to account for their formation.

*The Aberystwyth Beach Pebbles.*—Aberystwyth beach is well known amongst "pebble" collectors as one of the richest places on our coasts for Agates, Jasper, Onyx, and other polishable stones, which are largely gathered by the visitors. Chalk flints are also abundant, together with a great variety of Felsites, Porphyrites, Quartz Felsites, Granites, Greenstones, and Metamorphic rocks, also Mountain Limestone pebbles, often containing fossils. Only a very few of these pebbles can have come originally from any part of Wales, and I have only recognized two of the igneous and metamorphic pebbles as likely to be of Cymric origin, namely a Felsite from Llanbedrog and a serpentinous rock like those of the Lleyn Peninsula and Anglesea.

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[1] The common belief of the people is that the lakes are very deep, but all that I examined were shallow, the Teifi Pools and Llyn Gynon being from 7 to 33 feet, and Llyn Gwyddior, Llyn Bugeilyn, and Llyn Fyrddyn Fawr about 33 feet. Some of these measurements of depths were obtained by swimming across the lakes, and the rest by waiting till they were frozen over, when the ice was broken through with the hammer, and a line let down.

[2] Aberystwyth now obtains its water from this lake, and I am indebted to the engineer, Mr. Stooke, for information kindly sent me about the slopes of the lake bed, and the section of the moraine at its base.

I regard these beach pebbles as being derived from a Marine Boulder-clay now submerged in Cardigan Bay, out of which the pebbles are washed and carried up the shore by marine currents. It is probably just such a deposit as occurs on the south coast of the low ground in Anglesea and the Lleyn Peninsula, where I have found similar foreign pebbles.

*Eskers.*—Near Llanrysted Road Railway Station where the Ystwyth Valley opens out into a broad plain near the sea, a remarkable curved ridge of sands and gravels strikes right across the valley up to the river, which has cut through it on the west side. It is about 120 ft. high, and from the surrounding hills it has the appearance of a great terminal moraine. But its structure is totally different from moraine, consisting as it does of false-bedded coarse gravels, sands, and finely laminated loam and clay. The great majority of the stones are well rounded by attrition, and not a few are well striated by ice.

The matrix of the pebble-beds is a coarse sand, the particles not rounded, but rather like the fine sand left from lead washings, only finer. Other seams are altogether coarser in grain, and in places there are beds of finely laminated material which also contain a few stones, most of them angular. Altogether this ridge of gravel and sand bears much resemblance to, and seems to be the representative of, the Eskers of Ireland and the Kames of Scotland.

*Summary.*—Reviewing our results then, we find that in Central Wales there are abundant proofs of a severe glaciation of the country in the Great Ice age. The principal evidences are seen in the general features and contours of the hills and valleys, in finely polished and striated rock surfaces, in the stony clays or tills, the moraines, and erratic blocks. Excepting the extreme north and south, the glaciers were of strictly local origin, each confined to its own valley, there being no evidence of any confluence of the ice into a great *mer de glace.*

In the north the glaciers of North Wales overflowed into the Llyfnant Valley, and in the south the ice from the mountains of Caermarthenshire rose over the present watershed into the Teifi Valley and on to Cardigan.

Lakes and lakelets are numerous, and they are all rock basins; one of them (Llyn Llygad Rheidol) is probably ice-formed, and some others have morainic matter at their base, but the majority are so situated and of such construction that it is impossible to attribute *their formation* to the action of glacier-ice.

No evidence of any series of changing conditions such as a succession of cold periods, or an age of depression, has been discovered, but all the glacial phenomena of the district must be referred to one and the same glacial period when the country was covered with snow and local glaciers. The sands and gravels are either distinctly of fresh-water origin (as the Rheidol river gravels), or, as in the case of the Esker Ridge of Llanrhysted Road, of doubtful origin; and this latter I refer to the combined action of water and ice, the accumulation of ice causing special drainage conditions determining the position and influencing the construction of the deposit.

## III.—ON THE THEORY OF VORTICOSE EARTHQUAKE-SHOCKS.

By CHARLES DAVISON, B.A., Late Scholar of Emmanuel College, Cambridge.

EARTHQUAKE-SHOCKS have generally been divided into three classes:

*a.* Undulatory shocks, by far the most commonly felt, consisting of one or several waves, the movement at any place being to and fro along a line inclined to the horizon, but in general nearly horizontal.

*b.* "Sussultatore" shocks, consisting of one or more up-and-down movements, in a nearly vertical direction.

*c.* Vorticose shocks, consisting sometimes of a true rotatory motion, but generally, it would seem, of undulatory or "sussultatore" movements crossing one another in different directions, so that, it has been said, the surface of the ground appears like the irregular surges of a troubled sea.

It is with the last of these, the vorticose shocks, that we intend to deal in this paper; we shall also, however, point out one or two conclusions which may be drawn from their occurrence, and briefly state the connexion that subsists between the three kinds.

*Nature of Vorticose Shocks.*—The following descriptions of some vorticose shocks may be given in illustration of the above definition:

1845, Aug. 16, at Ragusa (Dalmatia), an earthquake, preceded and followed by loud subterranean noises; it was at first undulatory, afterwards vertical; it lasted 8 seconds.[1]

1858, Aug. 6, at Oneglia, an earthquake, which was at first vertical, afterwards undulatory from N. to S., and of 8 seconds duration.[2]

1812, March 26, at Caraccas. The first shock of this disastrous earthquake lasted 5 or 6 seconds. Immediately after this there was a second shock of from 10 to 12 seconds duration, during which the ground seemed to boil. Afterwards a subterranean noise louder than thunder preceded, by about 3 or 4 seconds, a vertical movement, followed by an undulatory movement, in which the shocks were from N. to S. and from E. to W.[3]

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[1] M. Perrey. "Liste les tremblements de terre ressentis pendant les années 1845 et 1848": Mém. de l'Acad. de Dijon, 1845-46.

[2] M. Perrey. "Note sur les tremblements de terre en 1858, etc.": Mém. Cour. de l'Acad. Roy. de Belgique (1861), Collection in 8vo. tome xii.

[3] M. Perrey. "Note historique sur les tremblements de terre des Antilles": Comptes Rendus (June 12, 1843), vol. xvi. pp. 1283-1303.

1881, July 5, Tokio, Japan. "At the commencement of the shock the motion was N. 112° E.; 1½ second after this the direction was N. 50° E.; ¾ second more it was N. 145° E.: and after a similar interval N. 62° E."[1]

1880, July 14-25, Manila, Luzon. July 14, 12·33 P.M.: "The horizontal pendulum [of the seismograph] inscribed a cross with arms almost at right angles, the first bearing from S.E. 10° E. to N.W. 10° W.; the second from S.W. 5° W. to N.E. 5° E." July 18, 12·40 P.M.: "when the great earthquake of oscillation, trepidation, and what is commonly called rotatory movement, occurred simultaneously. Its duration was 1m. 10s. It is impossible to describe all the movements of the pendulum on account of their number and variety." The principal directions were, however, from E. 5° S. to W. 5° N.; from S.W. to N.E.; and from N. 4° W. to S. 4° E. July 20, 3 P.M.: "the oscillation and trepidation movements alone were experienced, but with extraordinary violence. The oscillation of the pendulum was directed from S.E. 15° E. to N.W. 15° W. . . . . . The pendulum continued oscillating during the whole of the evening from N.E. to S.W." "At 10·40 P.M. a second shock occurred, in which the principal directions were from E. to W. and from N.E. to S.W.[2]

1854, Oct. 20, Coquimbo, Chili. Two shocks; the first was vertical, the second, which followed it immediately, was circular, and lasted 18 seconds.[3]

Many instances of a similar nature are to be found in the memoirs of M. Perrey and other seismologists. The descriptions, when given at all fully, seem to bear out the following conclusions:

1. The occurrence of shocks as vorticose shocks is dependent upon the position of the points of observation; for often during a given earthquake the nature of the shock varies throughout the disturbed area. Mr. Mallet's great work on the Neapolitan earthquake of 1857 affords an excellent example of this statement.

2. Vorticose shocks are generally felt as such only at places vertically, or nearly so, above the centre of disturbance. This fact, or its converse, seems to have been recognized both by Prof. Perrey and Mr. Mallet, the two founders of Seismology. "All is irregular, jerking, tumultuous at the centre of disturbance," says M. Perrey, "then, at a certain distance, the vibrations become more regular, and are propagated under the form of undulations perhaps isochronous."[4] The universal testimony of those who have experienced vertically arriving shocks, Mr. Mallet remarks, "is of a twisting and wriggling motion in different planes, violent in its changes of

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[1] Prof. J. Milne. Letter on "Earthquake Vibrations": Nature (Dec. 8, 1881), vol. xxv. p. 126.

[2] The above are notes of the principal shocks taken from the account by Father Faura of his observations and seismographic records at Manila: Proc. Roy. Soc. (Feb. 17, 1881), vol. xxxi. pp. 462-8.

[3] M. Perrey. "Note sur les tremblements de terre en 1857, etc.": Mém. Cour. de l'Acad. Roy. de Belgique (1860), Collection in 8vo. vol. x.

[4] M. Perrey. "Sur les tremblements de terre ressentis dans le bassin du Rhone": Ann. de la Soc. Roy. d'Agric. de Lyon (1845), vol. viii. pp. 265-370.

direction, and attended by a movement up and down of much greater range, to which the word 'sussultatore' is often applied."[1] We may further state in support of this fact:

*a.* That vorticose shocks often consist in part of vertical movements. This is noticeable in most of the instances given above, and in nearly all of those mentioned by M. Perrey.

*b.* That they are felt near those places which we gather from other evidence to be vertically above the centre of disturbance, the other evidence being: earlier occurrence in point of time, occurrence near the centre of the disturbed area, observations on the direction of the shock. Thus, in the Neapolitan earthquake of 1857, all the points where vorticose shocks were felt were near the place indicated by Mr. Mallet as the superficial position of the seismic focus.

*c.* That Humboldt remarks, when treating of rotatory shocks, that walls were observed to be twisted, but not thrown down by them (Cosmos, vol. i.). This implies a nearly vertical angle of emergence, and therefore proximity to the place (which we may call the *seismic vertex*) vertically above the centre of disturbance.

*d.* That vorticose shocks are sometimes preceded or followed by very feeble shocks felt only at or near the same places. Thus, the earthquake (at first vertical, afterwards undulatory) felt at Laybach, on Nov. 9, 1856,[2] was followed, about nine hours afterwards, by a feeble shock, which is not mentioned (as M. Perrey expressly states) as having been noticed at any other place. Now if a shock be so feeble that it can only just be felt within a very limited area at the surface of the earth, the centre of that area must be vertically above the seismic focus. Hence, assuming that both earthquakes originated at the same spot, this second shock corroborates our inference that Laybach was near the seismic vertex.

3. Vorticose shocks are usually of rather long duration, the average of over thirty cases in which the duration is explicitly stated being about 20 seconds. From this we must infer either that the cause producing the earthquake does not act instantaneously, or, more probably, that the seismic focus is of some magnitude. In the latter case, the velocity of the earthquake wave being about 800 feet per second, it follows that, if the duration of a shock be 20 seconds, the seismic focus must have been at least three miles long in one direction, for the time of vibration of each particle of rock is very small, probably only a fraction of a second. We may also add that, according to Mr. Mallet, the seismic focus of the Neapolitan earthquake of 1857 was a fissure nine geographical miles in length and three in height.

*Theory of Vorticose Shocks.*—Several explanations have been offered to account for vorticose shocks, and may here be briefly described, before proceeding to suggest what we believe to be their most probable cause. The first two, it should be remarked, were proposed before the publication, in 1846, of Mr. Mallet's paper on "The

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[1] Mr. R. Mallet. "The Neapolitan Earthquake of 1857," vol. i. p. 76.

[2] M. Perrey. "Note sur les tremblements de terre en 1856, etc.": Mém. Cour. de l'Acad. Roy. de Belgique (1859), Collection in 8vo. vol. viii.

Dynamics of Earthquakes," and therefore before the mechanism of earthquakes was clearly understood.

M. Ramond, who had for many years explored the Pyrenean range and experienced numerous earthquakes, says, "I have felt as many as ten or twelve shocks in the course of one night, and I am quite sure that, although the oscillations usually took place in the direction from north to south, the propagation was made in the direction of the chain, in such manner that all the rocks successively disturbed were found on the same parallel. This apparent contradiction is easy to explain: an explosion which traverses a series of distant cavities, must exert all its energy on their lateral walls, and impress on them movements of vibration, which open them and draw them together in a direction that crosses at right angles the line of propagation."[1]

Prof. Perrey suggests two theories, but does not state which he considers the more probable. One is similar to that of Baron Ramond; the other involves the hypothesis of a thin solid crust, and is as follows: "Let us admit at the internal surface of the solid crust of the globe (supposed fluid in the interior), an immense protuberance, a kind of mountain, which, to fix our ideas, we shall suppose directed parallel to the axis of an external valley, a great river-basin for example. Let us imagine the central nucleus, or a part of the materials which compose it, to strike this mountain at one of its extremities and in the direction of the axis of the chain; the movement will certainly propagate itself, according to the above hypothesis, along the axis of the external basin; but, on the other hand, will there not be produced derived movements which will manifest themselves outside on the flanks or slopes of the basin, by vibrations, diverging oscillations, or oscillations which will even be perpendicular to the axis of the basin."[2]

Mr. Mallet supposes these shocks to be caused by the transversely vibrating particles[3] describing curves similar to those in the annexed figure (Fig. 1). He considers that for small angles of emergence the transverse vibrations in nearly vertical planes are of very little importance, and may be neglected in comparison with the direct vibrations; but that for vertically arriving shocks the horizontal transverse movements would be powerful enough to cause the "twisting and wriggling motion, violent in its changes of direction," whilst the direct

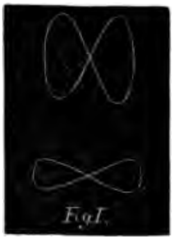

Fig. I.

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[1] Journal des Mines, vol. xii. pp. 95–96. Quoted by M. Perrey. "Mémoire sur les tremblements de terre ressentis en France, en Belgique et en Hollande, etc.": Mém. Cour. de l'Acad. Roy. de Bruxelles, vol. xviii. p. 103.

[2] M. Perrey. "Sur les tremblements de terre ressentis dans le bassin du Rhone": Ann. de la Soc. Roy. d'Agric. de Lyon (1845), vol. viii. p. 341.

[3] If a disturbance take place at any point of a homogeneous and isotropic solid, two spherical waves will diverge from that point with unequal velocities. In the first every particle moves approximately along a line joining it to the centre of disturbance, and the corresponding wave is said to consist of direct vibrations. In the second the particles vibrate in planes perpendicular to the lines joining them to the centre of disturbance, and are said to execute transverse vibrations.

vibrations would produce the attendant up-and-down, or "sussultatore," movement of greater range."[1]

Prof. J. Milne remarks that some of the Japanese earthquakes are compounded of direct and transverse vibrations, and he gives as an example the instance already quoted from his letter to *Nature.* It is quite possible, especially if the seismic focus be at no great depth and yet of some magnitude, that the direct and transverse waves may not have completely separated before reaching the surface of the earth,[2] in which case the vibrations of one wave will combine with those of the other, and will certainly produce shocks similar to those described above, provided the transverse vibrations are comparable in magnitude with the direct vibrations.

We come now to the theory which it is the principal object of this paper to explain, and we shall confine ourselves at first to the wave consisting of direct vibrations. If the seismic focus, or centre of disturbance, be a mathematical point, and the earth be supposed homogeneous and isotropic, the earthquake-wave at the surface will be of a circular form (because every plane section of a sphere is a circle), and the shock at any point will seem to come along the surface from the centre of the circle, *i.e.* from the seismic vertex. Hence, it follows that, if during an earthquake consisting of direct vibrations, the shock appears to one observer to come successively from different directions, there must be a seismic vertex corresponding to each direction, and a centre of disturbance to each seismic vertex, and therefore that the seismic focus cannot in this case be a mathematical point. (See also p. 259.)

Let us, then, investigate the effect at a point $P$ on the surface of the earth, of a disturbance proceeding from a seismic focus of any form and magnitude, and acting simultaneously throughout its whole extent, $P$ being within the area vertically above the seismic focus. With $P$ as centre imagine an infinite number of spheres, indefinitely near one another, and intersecting the focus, so that it may be supposed made up of the portions of the spheres included within it: and consider any one of these spherical portions. The disturbances from every point of it will reach $P$ at the same instant and will affect it simultaneously.

Now as, at any instant, the particle of rock at $P$ must be moving in some definite direction and with some definite velocity, we may suppose the disturbances from the corresponding sphere to be replaced by a disturbance at some equivalent point, the effect of which at $P$ will be exactly the same as that of all the disturbances together proceeding from the spherical portion considered; and the shock at P will appear to come in the direction from a point (which we may call the apparent seismic vertex) vertically above the equivalent centre.

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[1] Mr. R. Mallet. "Neapolitan Earthquake of 1857," vol. i. pp. 76-78.

[2] If $a$ and $b$ be the distances of the nearest and furthest points of the seismic focus from any place, $V$ the velocity of the direct wave, $v$ that of the transverse wave, and $\lambda$ the length of the former; the two waves will not have separated before reaching the given place if $\frac{b+\lambda}{V}$ is greater than $\frac{a}{v}$.

Corresponding, then, to the portion of each sphere included within the focus, there will be an equivalent centre of disturbance, and these equivalent centres will not coincide with one another, but their positions will be dependent upon the form of the seismic focus and upon the intensity of the disturbance at each point of it. If, however, the focus be such that any two points of it can be connected by a line lying wholly within it, and if the intensity vary continuously from point to point, the equivalent centres will lie upon a continuous curved line. It will be seen that for different positions of *P*, the distribution of equivalent centres may, and probably will, be entirely different.

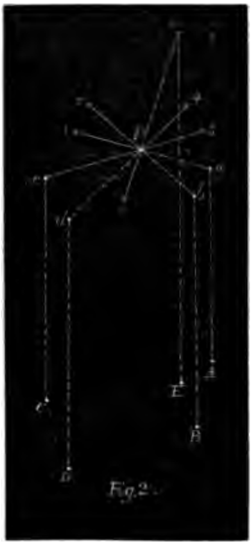

Fig. 2.

We may therefore suppose the seismic focus to be replaced by a number of equivalent points, and a corresponding disturbance at each point, each affecting *P* at a different instant of time. Suppose *A*, *B*, *C*, *D*, *E*, etc., to be the series of equivalent points for any point *P* on the surface of the earth (in the order in which the disturbances from them affect *P*) ; *a*, *b*, *c*, *d*, *e*, etc., the corresponding apparent seismic vertices. Then the disturbances at *P* will appear to come along the surface from *a*, *b*, *c*, *d*, *e*, etc., in the direction and order indicated by the numbered arrowheads.

Fixing our attention upon any one of the spherical portions, let us suppose, for a moment, the rest of the focus annihilated, and consider the motion of the particle at *P*. It will begin to move in some definite direction, and will continue to move until the molecular forces brought into action by its displacement compel it to stop ; it would then return nearly, or quite, to its original position, but before the movement is completed, disturbances from succeeding spheres will reach the point *P*, and will affect its subsequent motion, though not the vibratory character of that motion.

Hence, remembering that the earth's crust is seldom or never quite homogeneous and isotropic, that the seismic focus may be of any form and magnitude and may even consist of detached portions, that the disturbances at different points of the seismic focus are not necessarily of equal intensity, and that the disturbances do not necessarily take place simultaneously throughout the whole extent of the seismic focus, it is evident that we have a cause sufficient to produce any vorticose shock however complicated, and any variety in the changes of direction.

It will be seen also that the same reasoning may be applied to earth-waves consisting of transverse vibrations, whether these vibrations are executed in straight lines or curves.

As an illustration, let us take the case of a seismic focus (drawn elliptical in the figure, for simplicity) consisting of a fissure approximately plane, and inclined to the horizon; and let us consider the effect at a point *P* nearly above its upper end. The shock will consist of vibrations which will at first be nearly vertical (or "sussultatore"), but will gradually become more horizontal, their direction changing in the order indicated by the numbered arrowheads, so that the shock will end by being slightly rotatory in the direction of the curved arrow. If *P* be taken on the other side of the line *ab*, the rotary movement will be in the opposite direction. Lastly, if *P* be taken on or near *ab*, the shock will be at first vertical and afterwards undulatory in the direction *b* to *a*.

Sometimes vertical shocks of long duration are observed, as, for instance, the earthquake at Coquimbo on Feb. 25, 1853, which was described as being vertical and lasting 75 seconds. The seismic focus was probably a vertical plane fissure several miles in length, and the place of observation almost directly above its middle point.

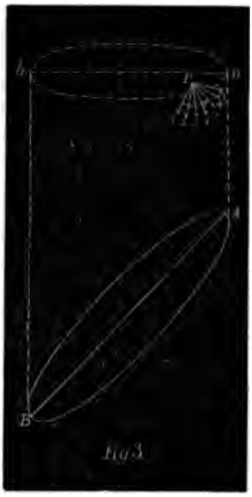

Fig 3.

Conversely, from the character of the vorticose shock as observed at two or more places, we might make important inferences regarding the nature and position of the corresponding seismic focus.

*Connexion between the three classes of Earthquake-shocks.*—The same method may be employed for investigating the effect of the earthquake at a point *P*, so distant that the seismic focus subtends at it only a small solid angle. The equivalent centres will lie very nearly on the straight line joining *P* to the centre of the focus, and therefore the shock will vary but slightly, if at all, in direction, and will be felt as a series of regular isochronous vibrations (varying, perhaps, in intensity), provided the seismic focus be such that any two points of it can be connected by a line lying wholly within it.

Thus we are led to the following conclusion: that the three different kinds of earthquakes, mentioned at the commencement of this paper, are not independent, but are different manifestations of the same phenomenon, the effect of the mere size of the seismic focus. If the focus be very small, a single undulation will be felt at all points of the disturbed area; if of medium size, the movement above it will be "sussultatore," in other parts undulatory; if it be large, the movement above it will be "sussultatore" and vorticose, in the immediate neighbourhood of the seismic vertex undulatory and vorticose, and in other places undulatory.

Again, since, in any given earthquake, the undulatory movement is felt over a very much larger area than the "sussultatore" and vorticose, it follows that the chance of its being felt as such is so much the greater, and therefore that undulatory shocks should be recorded very much more frequently than "sussultatore" and vorticose shocks.

*Twisting of Bodies during Earthquakes.*—Vorticose shocks being thus necessary consequences of a large seismic focus, it is but natural that we should recur to the explanation usually given by geologists of the twisting of bodies during earthquakes before the publication of Mr. Mallet's memoir[1] in 1846, and it will be noticed that the objection to the vorticose theory urged by Mr. Darwin (in 1839),[2] that under every object so turned there must have been a separate vorticose movement, loses its force on the view here presented.

Mr. Mallet recognizes two ways in which bodies may be twisted on their bases. (1.) "By the action of a single shock, when the centre of adherence of the base of the object lies to one side or other of the vertical plane passing through the centre of gravity and the line of the wave-path." (2.) By the conjoint action of two closely successive shocks in different directions. The second shock in the latter case he apparently supposes to be due to some cause distinct from that directly producing the first, but his description of the manner in which bodies are thus twisted being equally applicable to twisting by true vorticose shocks, we may here transcribe it.

"By the first shock the body is tilted up from its base, but not overthrown, so that for a time greater or less it rests wholly upon one edge of its base; while thus poised, if another shock should bear upon it in any direction transverse to the first, it acts as usual at the centre of gravity of the body, to displace it by inertia, in the contrary direction to the wave transit; but the body is held more or less by friction at the edge momentarily in contact with its support, and there only; but this edge must always lie to one side of the vertical plane passing through the centre of gravity in the direction of the [second] wave-path; hence the tilted body, while relapsing upon its base, also rotates round some point situated on the edge of its base upon which it had been tilted, and thus it comes to rest in a new position."[3]

*Application to the Theory of Earthquakes.*—We shall now point out two inferences which may be drawn from the occurrence of vorticose shocks, viewed in the light of the theory above described.

(1.) Upon this theory, vorticose shocks can only occur within a short distance of the seismic vertex, unless they should happen, in some exceptional cases, to be produced by some cause distinct from that producing the earthquake; and upon the two transverse-vibration theories this statement is also approximately true. As a general rule, therefore, we may consider the place where a vorticose shock is observed as nearly coincident with the seismic vertex. Seismographic maps of any region showing the positions of all the seismic vertices occurring within it, especially if the depths of the corresponding foci were also indicated, would doubtless lead to more accurate information concerning the relations of seismic foci to one another and to mountain ranges, etc., than can be obtained from a map, such as Mr. Mallet's, in which the whole area disturbed during each earthquake is coloured.

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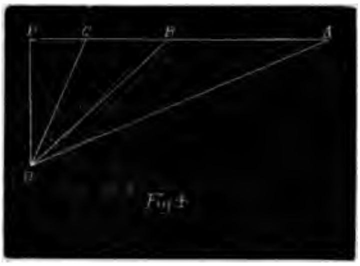
[1] "On the Dynamics of Earthquakes," Trans. Roy. Irish Academy (1846), vol. xxi. pp. 51-105.

[2] "Naturalist's Journal" (1879), p. 308.

[3] "Neapolitan Earthquake of 1857," vol. i. pp. 377-8.

(2.) Having given the position of the place where a vorticose or vertical shock is observed, and also the times at which the earthquake is felt at three places at different distances from the seismic vertex, and assuming that the velocity is the same along the radii drawn to these places, we can determine the depth of the seismic focus and the velocity of the earthquake-wave.



Thus, let $O$ be the seismic focus, $P$ the place where the vorticose shock is felt, so that $OP$ is nearly or quite vertical, and $A$, $B$, $C$, three places where the time of the shock is observed, and which we may (for simplicity of figure, and without loss of generality) suppose to be in a straight line. Let $PA = a$, $PB = b$, $PC = c$: $OP = z$, the depth of the seismic focus; $t$ the number of seconds between the occurrence of the shock at $C$ and at $A$, $t'$ between that at $C$ and at $B$: and $V$ the velocity of the earth-wave.

Then,

$$Vt = OA - OC = \sqrt{z^2 + a^2} - \sqrt{z^2 + c^2}.$$

$$Vt' = OB - OC = \sqrt{z^2 + b^2} - \sqrt{z^2 + c^2}.$$

Transposing and squaring each of these equations, we obtain—

$$2\,Vt\sqrt{z^2 + c^2} = a^2 - c^2 - V^2t^2 \quad \ldots \ldots \ldots \ldots \quad (1)$$

$$2\,Vt'\sqrt{z^2 + c^2} = b^2 - c^2 - V^2t'^2 \quad \ldots \ldots \ldots \ldots \quad (2)$$

$$\therefore \quad t'(a^2 - c^2 - V^2t^2) = t(b^2 - c^2 - V^2t'^2)$$

$$\therefore \quad V^2 = \frac{t'(a^2 - c^2) - t(b^2 - c^2)}{tt'(t - t')} \quad \ldots \ldots \ldots \quad (3)$$

From equation (3) we can find the value of $V$, which, substituted in (1) or (2), will give the value of $z$, *i.e.* the depth of the seismic focus.

If one of the places where the time is observed be that at which the vorticose shock is felt, $c = 0$, and the equations for determining $V$ and $z$ become

$$V^2 = \frac{t'a^2 - tb^2}{tt'(t - t')}, \text{ and } z = \frac{a^2 - V^2t^2}{2\,Vt}.$$

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## IV.—SUBSOIL DENUDATION OF BOULDER-CLAY.

### By T. MELLARD READE, F.G.S.

ON removing the superficial sand and soil to prepare for getting clay for brick-making, it is not unusual to find the surface of the Boulder-clay in this neighbourhood corrugated with tortuous channels. These channels are commonly filled with slutchy sand and gravel, which must be removed before the clay can be obtained.

At the present time there is an excellent example to be seen in Earle Road, Smithdown Road, Liverpool, next to the site of a new Board School that I am, as architect, superintending. The surface of the ground slopes rather quickly to the valley below, and the superficial strata consist of soil and a yellow subaërial quartzose sand, together from 4 to 5 feet deep, in which there are no stones or gravel.[1] This sand we are using for mortar, it being what is called "sharp," or consisting of angular grains. Below this the corrugations of the Boulder-clay are better developed than I have seen elsewhere, and give a clue to the origin of these channel-like depressions. They have just been cleared of the infilling, consisting of dirty clayey sand, gravel and stones, and their structure is clearly displayed. They are on the average about four feet wide, and three feet deep, but one reaches to over eight feet wide, and they wind about in the most indescribable fashion, but *none of them have any outlet* that I could discover, nor are they all connected. The sides of some of these channels slope on one side and are undercut on the other, that is, the clay overhangs the channel on one side. A few small boulders were included in the sand infilling.

The explanation of these curious channels appears to me to be this: they are cracks or shrinkages in the Boulder-clay widened by the constant very slow percolation of water—a somewhat parallel phenomenon to the "pipes" in chalk. The clay at the sides of the channels is quite yellow from the deposit of ochre washed out of the sand above. The gravel and stones are the undissolved portions of the Boulder-clay.

## V.—Traces of a Great Post-Glacial Flood.

### II. Evidence of the Loams and Brick-earths.

By H. H. Howorth, F.S.A.

(*Continued from p.* 231.)

If we now turn further east to Belgium and its borders, we shall find the same conclusion arrived at by inquirers. In the admirable memoir of M. d'Acy, already named, entitled "Limon des Plateaux du Nord de la France," the author has examined in great detail and with care the composition of the loamy mantle that overspreads the other surface deposits of Belgium and Picardy. His sections and descriptions show very clearly how its texture, passing from coarse materials in its bottom layers and gradually getting finer and more pulverulent in its upper ones, is such as we should expect from the effect of gravitation acting upon great masses of mud, etc., borne along by a rapid flood. And where the *limon* unites with the subjacent beds *in situ*, we see how the surface of the latter has been ploughed and eaten into in a most remarkable way, the *limon* filling up the hollows and holes torn in its surface as we should exactly expect. I will now quote a sentence or two from this work. He speaks of this Post-Glacial deposit, t occurs in Picardy, thus: "The stratification presented by this n, as well when it covers the plain as when it is superimposed the *diluvium gris* of the valleys, leaves no doubt that it was ned by running water, which could be none other, as M. Belgrand proved, than that of an immense inundation" (*op. cit.* p. 28). sing into Belgium, he describes its character in detail. He ies strongly against the fluviatile origin of the deposit, and adds: he *limons* which are found on these heights could therefore owe r origin to nothing *but an immense inundation* or diluvian catam" (*id.* p. 30).

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[1] This formation I have called "Washed drift sand." See "Post-Glacial Geology of the Mersey Estuary," Geol. Mag. 1872, p. 113.

e urges, as is the case in the Diluvium of France, that the shells id on the highest points of the water-shed separating the basin of Haine from the neighbouring basins, consist entirely of terrestrial ls. "If these deposits had been fluviatile, we should have had e river shells in them, and the circumstance that we have here terrestrial shells may best be explained by a cataclysm which red the whole country and buried these shells in the *limon* coning them" (*id.* 30).

he conditions are in fact the same as those I have urged in regard he loess and the *diluvium rouge* of the French writers. All these ace deposits seem to be subaerial, to represent the old land surface he period of the Mammoth, disturbed, re-arranged, and washed a mantle over hill and dale by a general inundation of water. ere we find the Diluvium separated into two layers, the lower as we have urged, seems clearly to represent the undisturbed l surface, while the upper one shows evidence everywhere of violent action of water.

peaking of the date of the cataclysm, M. d'Acy says, "It was t-Pliocene, posterior to the appearance of man in our country, and east in its later phases posterior to the definite scooping out of valleys, for 'the limon' which owes its origin to it descends n the plateaux to the very troughs of the valleys and covers there pockets and layers of *diluvium gris* in which the bones of the it Quaternary mammals and incontestable proofs of man's exis-e have occurred" (*id.* 34). Again, speaking of the "limon of the eaux" in the basin of the Haine at Spiennes and at Mesvin, he , "It has been deposited as we see it by diluvian waters posterior he appearance of man, and the last phase of the movement to ch the formation of the limon properly belongs took place r the valleys had received their present shape" (*id.* p. 36). aking of the *limon* at Mezieres at an elevation of 99 mètres re the sea-level, he tells us there have been found there in the e deposit specimens of *Succinea arenaria* and *Pupa muscorum*, luscs which do not live under the same conditions, and conse-ntly the fact of their being found together in the same stratum d only have resulted from the movement (*i.e.* the diluvial move-nt) which deposited the limon itself (*id.* p. 50).

. d'Acy finally sums up the result of his elaborate and detailed nination of the problem in this conclusion, "The limon of the eaux of the North of France and of Belgium was deposited by the great diluvial cataclysm which gave its present configuration to the country, and of which M. Belgrand has proved the existence" (*id.* 71).

Before we cross the Channel into England, it will not be inopportune to glance for a moment at the loamy deposits of South Russia, which, as we have seen, correspond to the Diluvium of the French writers. These deposits, which are found especially about the Sea of Azof and the Black Sea, are thus referred to by Murchison.

"In all the Central and Southern parts of European Russia," he says, "it is evident that such alluvium (*i.e.* deposit in South Russia containing Mammoths' remains) has been the result of currents of water, for it is piled up, and often tumultuously, in great thicknesses, and constitutes the chief banks of most of the streams, as well as the covering of numerous plateaux" (*op. cit.* p. 501).

Speaking of the deposits about Tagaurog, on the Sea of Azof, Murchison says this Mammoth drift is just as completely separated from any deposit resulting from existing agency, as the auriferous detritus and coarse clays on the sides of the Ural hills, or as the high mud-banks forming the cliffs of the great Siberian rivers and estuaries, for it covers the whole of the coast plateau, the present adjacent river Krinka and the Sea of Azof being 100 feet beneath it. *In truth, like similar drift over wide spaces of Central and Southern Russia, it is distributed at various levels, and most clearly indicates considerable submergence at the period when these animals were destroyed* (*id.* p. 502).

The problem on this side of the Channel is exactly parallel. We have in the Brick-earths of South Britain a repetition of what has been stated in regard to the Limon of Belgium. In some cases, as in the Thames Valley, it lies *in sitû*, and largely undisturbed, answering to the *diluvium gris* of the French writers, with the same contents and the same general features. Elsewhere, as over large districts in Kent and Sussex, it is spread as a finely sifted mantle over the high ground, answering completely to the *Limon des plateaux* of the Belgians. Let us first consider the Brick-earths found in the valleys such as that of the Thames. In regard to their contents, there is really no sensible difference between these deposits and that of the *diluvium gris*. In both cases the skeletons of mammals have been found entire, and the following graphic description by Mr. Boyd Dawkins of what was discovered at Ilford reads in effect like the similar descriptions at Cannstadt, etc. Speaking of the Uphall pit he says: "At the top there was the surface soil from one to three feet deep, then an irregularly stratified layer of brick-earth and gravel six feet, and lastly an irregular layer of flint gravel, underneath which was a fine reddish-grey sandy loam, four feet thick. All these had been cleared away, leaving a platform exposed, on which was a most remarkable accumulation of bones carefully left *in sitû* by the workmen. On the right hand was a huge tusk of a Mammoth eight feet long, with the spiral curvature undisturbed by the pressure of the superadjacent strata. Across it lay a remarkably fine antler of Red Deer. At a little distance was the frontal portion of the skull of an Urus, with its horn-cores perfect to the very tips, while around bones of various animals were scattered of Horse, Rhinoceros, Mammoth, Urus, either brown or grizzly Bear and Wolf" (Popular Science Review, vol. vii. p. 277).

Not only do the *débris* of the animals found in these deposits show that they perished here in hecatombs, as in Siberia, in Germany, and in France, but the correlated beds furnish proof of another kind of the violent character of the catastrophe by which the great mammalia were exterminated. Although not strictly within the area to which this paper is devoted, I would quote as a remarkable case the discovery of the Hippopotamus remains made in 1852 by Mr. Denny, near Leeds. Great portions of the skeletons of two or three large specimens of *Hippopotamus major* were there discovered at a height of 150 feet above the sea, and 20 feet above the banks of the Aire. The bones, says Mr. Denny, were discovered in a dark-blue sedimentary clay, almost approaching mud, and appear from their condition to have lived and died in the immediate vicinity. They were found drifted together with fragments of trees. The skeletons seem to have been complete when deposited, the vertebral column of one individual extended in a line across the trench, the ribs being *in situ*, and Mr. Denny considered that the animal must have been lying on its side (Denny, quoted by Tylor, Journ. Geol. Soc. vol. xxv. p. 64).

This discovery is most apposite. The Hippopotamus is essentially an amphibious animal, living most of its time in rivers, and accustomed to fluviatile floods. We can hardly suppose that three large specimens of the race should have been overwhelmed close together and close by a Mammoth and a Urus, whose remains were found in adjoining beds, by a mere flooded river, even when we postulate a pluvial period. They surely demand a much more overwhelming catastrophe.

If we turn from the contents of these beds to their internal structure, we shall find that while the lower portions of them bear the character, as we have said, of the *diluvium gris*, the upper beds bear on the contrary traces of a violent agitation. Take, for instance, the well-known section at Ilford. Above the beds containing the animal remains which were so largely collected by Sir Antonio Brady, there is, to use my friend Mr. Dawkins' words, "a layer of clay, brick-earth, and gravel (No. 5, in his section), irregular and twisted, and folded in a remarkable way, somewhat after the manner of the contorted drift on the Norfolk coast. It contains," he says, "pebbles of quartz, Lydian stone, sandstone, angular and waterworn flints, and fragments of grey wethers, one of which weighed 26 pounds. Some of the pebbles are imbedded with their long axes vertically, and therefore could not have been deposited by water." This stratum has been designated Loess by Mr. Prestwich, and it affords a good proof of the horizon on which these beds really exist. It agrees with the Loess, and also with the well-known beds in the Somme Valley, in various characters, and especially in the presence of these very stones with their long axes arranged vertically.

Mr. Dawkins in regard to the English beds, and Sir Charles Lyell in regard to the French, argue that this stratum bears unmistakable signs of having been accumulated by the action of ice, which has caught up the various materials of which it is formed, and deposited them on melting with the utmost irregularity, and they conclude that the climate was in consequence more severe than when the Mammalian remains were deposited (Lyell's Antiquity of Man, Dawkins' Early Man in Britain, p. 139). I am very suspicious indeed, as many other students are, of these alternating periods of extreme cold following one another at intervals, which are so frequently postulated by writers on Post-glacial times; and am equally suspicious of the constant appeal to the action of ice, which has become the *deus ex machina* of current geology. In the case before us the appeal is assuredly not warranted. We must remember that the occurrence of these vertical stones is not an isolated fact at Ilford, but is a feature of the Diluvium of the Somme Valley and of the Continental Loess, where the evidence of ice is assuredly very problematical. How could ice deposit layers of stones in this vertical way? If it was ground ice, it would rub them down and break them if they were not on their sides; while we cannot conceive floating ice—which, if it carries stones at all, carries the rolled stones, which it has ground into kidneys and boulders when still attached to its parent icefield—carrying and depositing in regular layers stones in vertical fashion in this way. Surely, as in Germany, the probability is that these unweathered stones have largely arisen *in situ* from the filtration of water charged with carbonate of lime which would naturally deposit concretions exactly in this way, the long axes being in the direction of the flow of filtering water. At all events there does not seem to be any really just ground for attributing the position of such stones to ice action. Putting ice aside, we are bound to conclude that the remarkably irregular, twisted and folded stratum which tops the brick-earth deposits at Ilford, and which is the last stage of that deposit, was due to nothing else than a violent flood of water, which "has caught up the various materials of which it is formed, and deposited them with the greatest irregularity." We have, in fact, a valuable piece of evidence going to support and strengthen the mass of facts forthcoming from the contemporary continental deposits, all pointing the same way. In fact, we could hardly have a stronger and more convincing proof of our contention that the period of the Mammoth was terminated by a great diluvial movement. Such a movement seems alone competent to account for a well-known, often quoted, and most interesting section in the Thames Valley, showing the transport, in one lump, of a great mass of Thanet Sands 38 feet in length and 7 feet 10 inches wide, having attached to it a portion of the Woolwich Pebble Bed, and a piece of the Woolwich Shell Bed 12 feet long and 6 feet 5 inches wide. The whole having been bodily removed and enveloped in purple clay. The section is well shown in the interesting paper by Mr. Skertchly (Journ. Geol. Soc. vol. xxv. p. 88). Mr. Tylor says of this case, "The difficulty is, to understand what kind of wash of water removed this incoherent mass of Thanet Sands, and deposited it again (without breaking it up into sand) 35 feet lower down upon a mass of the Woolwich beds, which must have descended 46 feet and changed places with the Thanet Sands" (*id.* p. 89). Surely the difficulty disappears in the presence of the explanation which we offer. This explanation explains completely the existence of these large masses of transported strata and of the great boulders of which Mr. Tylor, in fact, in another place says, "*These materials were evidently washed in by heavy floods, not confined to the valleys, but passing over the whole surface of the land,* tearing up the ground and carrying it to lower levels into the valleys" (*id.* pp. 60, 61).

If we turn from the deposits contained in the Thames Valley to the layer of brick-earth which covers upland and dale in the South of England, washed over the surface of the land evenly, we shall find it supporting the same apparently inevitable conclusion. It will be well first to show that this upland brick-earth corresponds to the limon of Belgium. In the first place it is found on the highlands. Thus it is found at Folkestone at 150 feet above the sea near the station, and in the words of Murchison, "it rises up upon the slopes of the adjacent chalk hills and you are insensibly conducted from the debris in the 'combe' or hollow to the wider but more thinly spread mass of similar matter on the slopes and summits of the hills." This mantle of brick-earth covers the drift gravels which occupy so much of the district, and has protected the bones, etc., they contain, from being destroyed. It is found, therefore, exactly as the upper limon of the French writers in some places in thick beds of clay, and in others thinning out and evidently resulting from the same effects of a wave of translation which has buried the Mammoth and his companions in so many other places. Speaking of Kent, Murchison says, "Fossil bones of Mammoth, Rhinoceros, Hippopotamus, Stag, Horse, etc., have been found, as I was informed by Mr. Bensted, in the excavation of brick-earth and flint drift on the slopes above the jail at Maidstone, which I had examined, and not less than 80 feet above the river. Dr. Plomley, indeed, gave me specimens of the teeth of *Rhinoceros tichorhinus* which had been found there. *Fresh-water and land shells also occurred in some of the overlying loam, and the whole case is therefore precisely in accordance with that of other places cited.* No one can separate this drift of the summits of Pennenden and Barming Heaths from the bone drift of Maidstone" (Journ. Geol. Soc. vol. vii. p. 382, note). Again, the chief localities where fossil mammalia occur in this part of Kent have, indeed, been clearly described by Prof. Morris (Loudon's Mag. Nat. Hist. vol. ix. p. 593, 1836); and this good naturalist informs us that the species of shells (*Helix hispida*, *Pupa marginata* and *Succinea oblonga*), found usually in the upper (loamy) portion of the detritus, belong to land testacea and to such as "inhabit the banks of rivers and marshy places, no decidedly fresh-water shell having yet been detected," while the large fossil bones lie in the lower mass and under the clay (*id.* p. 383). This is precisely as in Belgium and in France, and the same explanation of it is given by Murchison as that given by M. d'Acy and other continental inquirers. He also postulates as necessary to account for its distribution a great flood of waters. His words are, "It may also be well imagined how, in this pounding back of the waters, the coarser and heavier materials would be collocated, just as we now find them, and how the stiff loam resulting from the final settlement of the smaller particles of matter in the turbid water would naturally form the covering of the stony debris. . . . The abundance of bones in such hollows can be only, I imagine, satisfactorily explained by supposing that the animals were drifted into these depressions and entombed beneath the masses of detritus" (*id.* p. 378). Mr. Mackie, in his account of the well-known deposit at Folkestone, tells us how the "lower portion of it contains a considerable number of the remains of Elephant, Ox, Stag, Hyæna, Hippopotamus, Irish Deer, etc., and in the marly portion (*i.e.* the upper layer) numerous specimens of two or three species of *Helix*. No fluviatile molluscs have as yet been found. The bones and shells are found both in the gravel and in the calcareous marl above it." Mr. Mackie also says, "The whole of the bone bed appears to have been subject to the action of water, as the flints and grit boulders, although angular, are partially worn (*i.e.* like the *diluvium rouge* of the French writers), and the chalk nodules and softer pebbles are completely rounded. The stratification also of the marl sand and boulders follows the irregularities of the Lower Greensand on which it rests" (*id.* p. 260).

Wherever we turn, it seems that the loamy deposits of Central Europe bear one consistent testimony to the existence of a vast translating wave of waters which closed the Mammoth period, and which I have designated the Great Post-Glacial Flood. In another paper I hope to deal with the evidence of the Valley Terraces.

## VI.—ON THE CLASSIFICATION OF THE EUROPEAN ROCKS KNOWN AS PERMIAN AND TRIAS.

By the Rev. A. IRVING, B.Sc., B.A., F.G.S.;
Senior Science Master of Wellington College.

(*Continued from p.* 223.)

ANY geologist who has spent a short time at Eisenach, and has examined any of the numerous road- and hill-side sections in the district about the celebrated Wartburg, must have been struck, as I was myself several years ago, with the enormous development of the breccias and conglomerates interbedded with well-stratified sandstones and marls; and this district is fairly typical of the Thüringerwald. For an account of these the reader must be referred to *Siluria*, to the paper by Murchison and Morris before mentioned, and to Credner. The former writers remark: "The movements by which the great brecciated masses were aggregated were clearly suspended and repeated many times; the intervals of quiescence allowing of those deposits of finely triturated red sand and marl which alternate with the coarse and subangular conglomerates. . . . These breccias and conglomerates, with their associated sandstones, are of gigantic dimensions, and have been bored into in fruitless searches after coal to a depth of about 2500 English feet." (Here is surely something more than a mere appendage to the Carboniferous.) The corresponding strata which lie to the south of the Harz Range are not of such gigantic dimensions; otherwise a similar description applies to them.

The sequence of things in the later Palæozoic times has been so well generalized by Credner in the form of a table that I take the liberty here of transcribing it:

| | | | | | |
|---|---|---|---|---|---|
| 5. *Deep Sea.* | Marine formations. | Limestone. | Marine animal-remains. | *Zechstein*; | Dyas. |
| 4. *Subsidence* under the sea. | Shore formations. | Conglomerates and Sandstones. | | *Rothliegendes*; | |
| ……………… *General Unconformity.* ("*häufige Discordanz.*")……………… | | | | | |
| 3. *Stationary* condition broken by insignificant oscillations. | Freshwater and marsh formations broken by shore and shallow sea formations. | Coal-bearing strata. | Land-plants. | *Coal-bearing Rothliegendes*<br>*and productive Coal-measures*; | Carboniferous. |
| 2. *Elevation* above the sea. | Shore formations. | Conglomerates and Sandstones. | | *Sandstones without Coal-seams*; *Culm*; | |
| 1. *Deep Sea.* | Marine formations. | Limestone. | Marine animal-remains. | *Carboniferous Limestone*; | |

The only point which seems open to question here is the use of making a break between the lower coal-bearing Rothliegende and the Coal-measures proper, especially as the discordancy of the strata is more generally above than below them. Of course the German geologists must have good reasons for this, and are no doubt convinced that upon the whole it is required by the general facies of the plant-remains which characterize these lower Rothliegende. On the other hand, it would appear that such reasons ought to be very strong indeed, when simplicity would suggest the grouping of them with the Coal-measures.

In the South Staffordshire area we come across a series of sandstones and conglomerates, especially about the Licky and Clent Hills, in which the counterpart of the German Rothliegende seems to be met with. The best description of these is perhaps to be found in the Survey Memoir of the district, before referred to, by Mr. Jukes. That author estimated the thickness of the series at about 1,500 feet. The included fragments, many of which are a foot and a foot and a half in diameter, are derived in about equal proportions from "trappean" and other rocks, many of the latter being of Silurian age. They are unconformable to the older rocks upon which they lie, inclusive of the Coal-measures. Mr. Jukes's description gives us a picture of a series of deposits filling up the creeks and bays of an older Palæozoic region, and occupying a position in relation to it similar to that which is occupied by the Rothliegende of Germany in relation to the older rocks.

In the Warwickshire area the case seems to be more doubtful. Here the strata called Permian are generally *conformable to the Coal-measures,* and present great uniformity of character throughout. Their resemblance to the sandstone and marl series which *underlies* the Permian breccias of South Staffordshire is pointed out by Mr. Howell (*loc. suprà cit.*) as having been first observed by Sir Andrew Ramsay, and as having led him to suggest the removal of them from their previous classification with the Triassic strata, with which they are unconformable. The palæontological evidence which they afford is very meagre, and of itself scarcely sufficient to justify their separation from the Carboniferous series. The included fragments of the specimens of the conglomerates of the series which I have seen are nearly all well-rounded water-worn pebbles, or broken pebbles, and a very high per-centage of them, the great majority in fact, consist of Carboniferous Limestone; their formation must therefore have taken place at some time subsequent to the induration and exposure to degrading influences of the strata of that formation. The areas of their deposition were evidently more exposed to the surf-action of a tidal sea than were those in which the Permian breccias further to the west were formed. On the assumption that the so-called Warwickshire Permians are stained Upper Coal-measures, it remains yet, I think, to be shown why they are so much more marly than the strata of that formation, and why the change in the colour of the soil and in the general character of the country should be so marked as it is in passing from one set of strata to the other. The question of "staining" by percolating waters is not so simple as it is thought, by some writers who speak of "stained Carboniferous" strata. The action of free atmospheric oxygen held in physical solution by rain-water in converting lower oxides of iron into the red peroxide can be understood readily; but how water can carry down this insoluble peroxide (as seems to be assumed in some quarters), so as to furnish a red cementing material for strata below, is not so clearly made out. We ought therefore to be cautious in accounting in this way for the great difference observable in the prevailing colour of two contiguous series of strata, when both have been exposed for an immense time to the action of atmospheric oxygen. Of course the reducing action of carbonaceous matter present in the one series may prevent the extreme stage of oxidation which takes place in the other, in which carbonaceous matter is wanting; but to admit this would be to go far to surrender the point at issue. The same may be said, if it be urged that one series is more pervious to water than the other. On chemical grounds, I am strongly inclined to believe that the coloration of the two great Red Series was (for the most part) *contemporaneous with their deposition,* and furnishes strong evidence of the "continental" conditions under which that took place. For these reasons I think the case of the Warwickshire Permians still an open question.

### *On the Relation of the Bunter to the Keuper.*

It is well worthy of note that, as the investigation of the Trias of England proceeds, the break between the Bunter and the Keuper formations becomes more pronounced: it may in fact be said now to be at least as great as that which exists between the Bunter and the Permian, in the most important (the north-eastern) area. In Cheshire and in Shropshire, the massive series of sandstones so much worked for building-stone, forms the base of the Keuper, but on the east side of the Pennine axis these lower members of the formation are only feebly represented. A definite "basement-bed" has, however, been traced of late for the Keuper, over a good portion of Notts and Derbyshire, through the labours of Messrs. E. Wilson and Shipman, whose papers appeared a short time ago in this MAGAZINE, and in the *Midland Naturalist.* The calcareous breccia (which is in places dolomitic) has been found, through the extension of building and engineering works, to be more generally distributed, than was supposed a few years ago; it has been found, in fact, capping Bramcote Hill and the remarkable rock known as the Himlack Stone, but a few miles west of Nottingham. The hard red conglomerate, the existence of which, on the east of Nottingham, was indicated by the writer some years ago,[1] has been traced over a pretty wide area. These results have been accepted by Mr. Aveline.[2] In its calcareous, and occasionally dolomitic character, this basement bed agrees with the lower members of the Keuper of Germany, where it is closely related to the Muschelkalk, and where distinct calcareous and dolomitic bands are of common occurrence.[3]

At this point it may be of service to remind geologists of one or two interesting facts about the Muschelkalk of Germany, so that the importance of the break between the Bunter and Keuper in the northern counties of England may be fully recognized, and the confusion of ideas favoured by the introduction of the name *Trias,* which has led to the hope of finding the Muschelkalk formation represented in England, may be eliminated from the subject. If such a hope is still entertained in some quarters, it is worth while to consider—1. The discontinuity of Upper Bunter over the conglomeratic or middle series of that formation, and the frequent evidences of local erosion and of unconformability, all pointing to the elevation of a considerable portion of the English New Red area in the immediate Pre-Keuperian age. 2. That the Muschelkalk itself undergoes a marked change as it is followed in the direction of the British area. This great formation, in parts of Germany where it is fully developed (*e.g.* to the south of the Harz, in Thüringia, in Hesse, in North Bavaria, in Würtemberg, and in Baden), is made up of the following well-marked members:—

| | | | | | |
|---|---|---|---|---|---|
| Upper Muschelkalk | ('Hauptmuschelkalk'), | .. | thickness | 50—150 | mètres. |
| Middle ,, | ('Anhydrite Group'), | .. | ,, | 30—100 | ,, |
| Lower ,, | ('Wellenkalk') | .. | ,, | 60—120 | ,, |

It assumes however to the west of the Rhine (in the Lorraine hill-country, about the northern half of the Vosges, between Luxemburg and Trêves, and in parts of the Eifel) a very different character, sandstones and marls (containing Muschelkalk fossils) replacing in some places (*e.g.* about Saarbrück) the limestone, while the whole formation becomes greatly attenuated, until at last (*e.g.* on the Attert) the thickness of the Muschelkalk has dwindled to four feet and even to a foot. "This extraordinarily feeble development of the Muschelkalk prepares us for the English facies of the Trias, where the Keuper lies directly upon the Bunter Sandstone." (Credner).

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[1] *Vide* Proceedings of the Geologists' Association, vol. iv.

[2] *Vide* Mr. Aveline's Memoir previously referred to; also the GEOL. MAG. for 1881 (pp. 396, 523), and the vols. for 1880 (p. 308), and for 1879 (p. 352).

[3] Credner, *El. d. Géol.* (p. 510), and the Table on pp. 512, 513.

### *Palæontological Evidence.*

In recent discussions on this subject there would appear to be sometimes a want of sympathy between the physical geologist and the palæontologist, and a tendency on the part of the former to attach too slight a value to the evidence furnished by the remains of the fauna and flora of the Permian and Triassic ages. Conclusions as to the true relation of these two systems to one another must not be drawn from physical evidence alone, as it is furnished in particular and limited areas. There is no doubt that if such evidence were admitted as of primary value, a great deal might be said to establish a continuity between the Permian and Trias, and to justify the grouping of them both in one system. This was pointed out some years ago by the late Prof. Phillips with reference to the Worcestershire and Warwickshire districts,[1] and a good deal has been written since then on the succession of the strata as it is presented to us in the north-eastern and north-western areas of England, where, as we have shown, the break in the one area between the Permian and the Trias is not nearly so great as was at one time supposed, while in the other area there is no physical break at all, in one portion at least. We may go further, and point to the succession of the same great group of strata as it occurs in Germany. In that country, as pointed out long ago by Murchison,[2] "no physical dismemberment has been observed, which separates the strata accumulated at the close of the Permian period from those formed in the earliest period of the Trias, the summit of the one being everywhere conformable to the base of the other."

The excellent monograph of King on the fauna of the British Permians is too well known to need more than a passing mention here. It may, however, be useful to add a few remarks and generalizations from so high an authority as Credner.[3]

The *flora* of the *Dyas*, he points out, is closely allied to the Carboniferous flora, and represents the latest remains and traces of a vanishing Palæozoic world, consisting mostly of marsh- and shore-forms (mainly confined to the Rothliegende), with *Caulerpites* representing marine forms. Though poor in forms of life, both flora and fauna have a definite Palæozoic 'character,' and are closely allied to those of Carboniferous times. The Post-Carboniferous flora consists (with the exception of a few lower forms) of Cycads, Conifers,

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[1] *Geology of Oxford and the Valley of the Thames*, chap. viii.

[2] Murchison and Morris, in Q.J.G.S., vol. xi.

[3] *El. de Géol.* pp. 466, *et seq.*

Ferns, and Calamites, and therefore in by far the greatest proportion of land-plants. Among these, and ranging backwards through Carboniferous to the Middle Devonian, the well-developed genera *Calamites* (with the highly characteristic *C. gigas*, Brong.), *Annularia, Asterophyllites, Sphenopteris, Odontopteris*, are met with in numerous species; also the genus *Cyatheites* (*C. arborescens*) is widely spread, and the Carboniferous cycad-genus *Noeggerathia* equally so. On the other hand, *Lepidodendron* is of much rarer occurrence than in the Carboniferous period; *Sigillaria* and *Stigmaria* have almost completely died out. The stems of the Tree-ferns of this period are preserved in greater perfection and beauty through the silicification of their tissues, and on this account, as well as on account of their general prevalence, they are to be regarded as very characteristic of the Post-Carboniferous period. To these belong *Psaronarius* and *Tubicaulis*. Great significance attaches to the genus *Walchia*, with its closely-packed angular leaves. The remains of the land-flora of the period are in the main confined to the Rothliegende or lower member of the Dyas; but the marine group of strata above these furnishes commonly Fucoids (*e.g. Caulerpites*), and along with these drifted ferns, and especially the twigs and fruits (their forms preserved as iron-pyrites) of a conifer (*Ullmannia Bronni*, Göpp.) allied to *Cupressus sempervirens*. [According to Sir Charles Lyell,[1] about 18 or 20 species are known in the Permian rocks of England, and no less than 60 in those of Saxony.]

If now we compare the floras of the *Dyas* and *Trias*, a decided difference is observable. According to Credner, the *Equiseta* (*E. arenaceum* and *E. columnare*), which in the Trias appear for the first time, are widely distributed, not only over Europe, but also over the east of North America. The *genera* of Triassic ferns are new except *Pæcopteris* and *Tæniopteris*. While in the Palæozoic period vascular cryptogams make up almost exclusively the flora, they recede far into the background in Triassic times, and more especially in Keuperian times, before the development of Cycads and Conifers. The flora of the Muschelkalk is limited to a few questionable *Algæ*, and small drifted fragments of ferns. In the earlier Triassic period the older genera of ferns are superseded by *Anomopteris, Clathropteris, Gutbieria, Sagenopteris*. Among Cycads appear *Pterophyllum, Zamites, Otozamites*, and *Pterozamites*, and among Conifers, *Voltzia* and *Albertia*.

[Sir Charles Lyell remarked in *Student's Elements* (p. 384) that "upon the whole the plants of the Marl-slate (the base of the Magnesian Limestone in the North of England) differ considerably from those of the Coal-period; the plants of the Rothliegende of Germany show a close generic affinity with Carboniferous forms." A considerable addition has recently been made to the known flora of the Marl-slate series of this country by the labours of Mr. E. Wilson, F.G.S., who has collected a great number of specimens from this formation, owing to its exposure in railway cuttings in Nottinghamshire. Mr. Carruthers has pronounced many of them to be forms which, though known on the Continent, had been hitherto almost unknown in this country.[1]]

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[1] *Student's Elements of Geology*, p. 383.

(*To be concluded in our next Number.*)

## NOTICES OF MEMOIRS.

### On the Geology of the Færöe Islands. By James Geikie, LL.D., F.R.S., etc. [Trans. Roy. Soc. Edin. 1882, vol. xxx. part 1.]

In this Memoir the author gives an account of observations made in company with Mr. Amund Helland of Christiania, during the year 1879; while at the same time he reviews the work done previously by other geologists and travellers. The islands are essentially volcanic; only two of them, Myggenæs and Suderöe, containing layers of clay, shale, and coal, intercalated with the basalts, which are the principal rocks. The coal (probably of Miocene age) occurs as more or less lenticular layers in beds of dark indurated clay and shale. The seams, therefore, are very inconstant, and thicken and thin out in the most irregular manner. Indeed, Dr. Geikie observes that it is not difficult to trace the passage from coal into shale—an appearance which, taken in connexion with the general aspect of the beds, is strongly suggestive of the aqueous formation of the coal-seams. He saw no traces of a true underclay, and nothing resembling rootlets.

The volcanic rocks consist of bedded basalts (chiefly anamesite) with layers of tuff. among which are sometimes intruded veins and sheets of basalt. This is the case in Suderöe, where the coal-bearing beds appear to have been lines of weakness, yielding more readily to the assaults of the intrusive basalt than the harder and less easily divided anamesites with which they are associated, for nowhere else in the island do such intrusive sheets occur.

Discussing the origin of the volcanic rocks, the author comes to the conclusion that they must have been erupted from a centre or centres, removed some distance from the site of the present islands—a conclusion which explains the absence of breccias and agglomerates, of lapilli and bombs.

The great series of basalt beds and tuffs (13,000 or 14,000 feet in thickness) most probably accumulated on the outskirts of an old volcanic area. They represent the heavier and more fluid lavas, derived from foci which most likely ejected other materials unable to reach distances attained by basalts.

There seems no reason to doubt that these igneous rocks belong to the same great series of which the basalt plateaux of Iceland, Greenland, Spitzbergen, and the Scottish Islands form separate portions, and which are referred to the Miocene period. The author gives an interesting sketch of the physical conditions under which the rocks of the Færöe Islands would seem to have been accumulated.

The principal object of his journey, however, was to examine the

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[1] *Vide Midland Naturalist*, vol. iv. p. 122.

Glacial phenomena of the islands. Reminiscences of the "Great Ice Age" were met with on every island visited. Sometimes the striæ were finely preserved, at other times they were faint, and only the deeper ruts were conspicuous upon the smoothed faces; while in very many cases all the more delicate ice-markings had disappeared, and only the characteristic rounded and dome-shaped outlines remained.

The Till or Boulder-clay, not often so much as 15 feet in thickness, closely resembled the similar deposit which occurs in the hilly and mountainous districts of Scotland. It lay either upon low undulating grounds, or was closely packed together behind rocks, whose abraded and ice-worn faces were quite destitute of any such covering. All the stones and boulders in the Till were of local origin, and in the many exposures which were examined, no fragment which might not have been derived from the islands themselves was found. All consisted of basalt rocks and tuff, and chiefly of the former. This Till, in the author's opinion, represents the ground-moraine of the old ice-sheet that covered the islands.

All the little lakes, with one or two exceptions, were found to occupy true rock-basins, excavated by ice-action under varying conditions.

To many interesting matters we must but briefly allude under the headings of the "Origin of the Valleys and Fiords," "Atmospheric Erosion," "Former Greater Rainfall," "Marine Erosion," and lastly "Peat and Buried Trees"—all of which, besides other subjects, are treated more or less fully, according to the information he could gather, and always in the lucid and graphic style so characteristic of the author.

The memoir is illustrated by a map and three plates of sections.

## REVIEWS.

### THE SWISS PALÆONTOGRAPHICAL SOCIETY.

MONOGRAPHIE PALÉONTOLOGIQUE DES COUCHES DE LA ZONE À *AMMONITES TENUILOBATUS* D'OBERBUCHSITTEN ET DE WANGEN (SOLEURE). Mem. de la Soc. Pal. Suisse, vol. vii. 1881.

THE indefatigable M. de Loriol has recently completed the above monograph, though it is not quite four years since there appeared a notice in the GEOL. MAG. (Aug. 1878, p. 354) of a similar monograph by the same author of these very "Badener Schichten" as they occur in the adjoining Canton of Argovie.

At the risk of being charged with forcing an open door, M. de Loriol is not satisfied with a simple comparison of the zone in the two localities, such as mere statements or lists of fossils might convey; but he devotes a full palæontographical memoir to the subject, embracing about 87 species, many of which were amply figured and described in the previous monograph.

Fourteen fine quarto plates of fossils with text are given in the best style of the Swiss Palæontographical Society for the benefit of those who are not satisfied by a simple examination of the table that there exists in Soleure a bed (No. 8 of the section), in which are found together species belonging to the zone of *Am. tenuilobatus*, and many others belonging to the "Astartien" proper; and that consequently the zone of *Am. tenuilobatus* is a facies of the "Astartien" or upper "Sequanien." W. H. H.

# REPORTS AND PROCEEDINGS.

## GEOLOGICAL SOCIETY OF LONDON.

I.—March 22, 1882.—J. W. Hulke, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On a Fossil Species of *Camptoceras*, a Freshwater Mollusc, from the Eocene of Sheerness." By Lieut.-Colonel H. H. Godwin-Austen, F.R.S., F.G.S.

In this paper the author described a new species of fossil mollusc from the upper part of the London Clay, near Sheerness, where it was discovered by Mr. W. H. Shrubsole. He referred it to the genus *Camptoceras*, Benson, a recent fresh-water type, hitherto known only from three species found in widely separated localities in India by different naturalists. The genus has a sinistrorse shell, with disunited whorls; and the species, which the author named *Camptoceras priscum*, is elongate, with the apex very acuminate and slightly curved, and consists of four whorls rather rapidly increasing and constricted at intervals, then becoming tumid. The surface shows slight indications of spiral ribbing in the casts. The aperture is not distinctly shown, but was evidently oblique, circular or oblate, and slightly reflected. The length of the shell was about a quarter of an inch. Numerous specimens were obtained in a single fragment of clay.

2. "Note on the Os Pubis and Ischium of *Ornithopsis eucamerotus* (synonyms—*Eucamerotus*, Hulke; *Bothriospondylus* (in part), R. Owen; *Chondrosteatosaurus*, R. Owen)." By J. W. Hulke, Esq., F.R.S., Pres.G.S.

In this paper the author reviewed the various contributions to the knowledge of this Dinosaur, for which he adopted Prof. Seeley's generic name *Ornithopsis*, and employed the name *eucamerotus*, originally applied by him to the genus as the specific name. He also discussed the affinities existing between *Ornithopsis* and certain other Dinosaurs, such as *Ceteosaurus* and the American genera *Camarasaurus*, *Atlantosaurus*, and *Brontosaurus*. He then described the pubis and ischium which have recently been acquired by the British Museum from the collection of the late Rev. W. Fox, by whom they were purchased, together with the finest typical thoracic vertebræ of *Ornithopsis*. The pubis was described as an oblong, flattened, nearly straight bar, about 11 inches wide in the middle and broader at the two ends, with an oval foramen in the acetabular dilatation of the proximal part, which unites by a straight suture with the anterior dilatation of the ischium; the latter is narrower, stouter, and more curved than the pubis. The length of the pubis is about 29 inches, and that of the ischium about 26 inches. At the proximal end of the ischium there is a posterior process which united with the ilium and formed the posterior boundary of the acetabulum, the inner border of this and the posterior part of the proximal surface of the pubis forming a common curve belonging to the acetabulum. The author campared the arrangement with that found in *Atlantosaurus immanis*, Marsh.

3. "On *Neusticosaurus pusillus* (Fraas), an Amphibious Reptile having Affinities with the Terrestrial Nothosauria and with the Marine Plesiosauria." By Prof. H. G. Seeley, F.R.S., F.G.S.

These remains come from the Lettenkohle, a stratum between the Upper Muschelkalk and Keuper, and were obtained at Hoheneck, about nine miles north of Stuttgart. They have been already noticed by Dr. Fraas under the name of *Simosaurus pusillus*; but the palate differs much from that of this genus, and from all others that are known. *Neusticosaurus* is the smallest representative of the Plesiosauria yet known, and has a special interest as exhibiting hind limbs with the characteristics of a terrestrial animal, while the fore limbs are modified into paddles. Two specimens have been obtained. The extreme length of the skeleton of the larger is about 270 millms., and, with the exception of the abdominal ribs and some parts of the pelvic girdle, it is perfect. The author describes minutely the various parts of the skeleton, concluding with some remarks on the affinities of the Crocodiles with the Plesiosaurs. *Neusticosaurus* indicates that the latter had ancestors which were terrestrial in habit.

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II.—April 5, 1882.—J. W. Hulke, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "Geological Age of the Taconic System." By Prof. J. D. Dana, F.M.G.S.

The author takes exception to some remarks made before the Geological Society by Dr. T. Sterry Hunt on the 16th November last. Dr. Sterry Hunt has thrown doubt on the results arrived at by the geologists who have studied the relations of the so-called Taconic strata, not in consequence of any observations of his own, but on the general ground that "where newer strata are in unconformable contact with older ones, the effect of lateral movements of compression, involving the two series, is generally to cause the newer and more yielding strata to dip towards, and even beneath the edge of the older rock—a result due to folds, often with inversion, sometimes passing into faults."

It was pointed out in opposition to these views, that the observations of Emmons, H. D. and W. B. Rogers, Mather, Sir W. Logan, James Hall, E. Hitchcock, C. H. Hitchcock, Hager, and Wing, prove that the Taconic schists and limestones are in conformable succession and of Silurian age. The stratigraphical structure of the Taconic range is, indeed, so simple that all observers who have studied it have described the schists and limestones as conformable; and numerous characteristic Silurian fossils have been found in both. This view had been maintained by Sterry Hunt himself till 1878, when he first propounded his new interpretations of the strata in question; but the latter was not based on any fresh facts or observations.

The author's own observations on the subject, carried on during many years, were detailed and illustrated by a map of the whole of the Taconic range. In conclusion, he pointed out that, even if Dr. Sterry Hunt's general principle were conceded, and he was not by any means himself prepared to make such a concession, it would have no bearing on the point at issue; for the supposed younger strata do not dip against the Taconic schists. In opposition to the view that the geological age of strata can be inferred from their mineral characters, he pointed out what remarkably different rocks have been produced by the metamorphism, in different degrees, of the strata of the Taconic range.

2. "On some Nodular Felsites in the Bala Group of North Wales." By Prof. T. G. Bonney, M.A., F.R.S., Sec. G.S.

These peculiar felsites are chiefly found in one or two localities in the neighbourhood of Bettws-y-Coed and of Conway. In the former case, in the same mass, are found ordinary compact felsite, exhibiting under the microscope fluidal structure, a peculiar rock, resembling a greenish schist, and various nodular felsites (with cleavage) showing nodules sometimes 3 or 4 inches in diameter, some being solid, others hollow, or more or less filled with chalcedony, chlorite, chalybite, etc. The nodules never exhibit a radial structure, and there is no difference of importance between their structure and that of the ordinary rock. The author showed that the schisty rock is only an amygdaloidal felsite, in which, after cleavage, a secondary (micaceous?) mineral has been deposited along the cleavage-planes. As regards the nodular structure, he showed that it is analogous to the spheroidal structure seen on a large scale in many igneous rocks, and on a smaller scale in perlite, and gave reasons for its being frequently associated with vesicular cavities. The infiltration of these cavities and consequent solidification was almost certainly prior to the production of the cleavage-surfaces, which are distorted by them. The Conway felsites exhibit similar phenomena, except that they are practically uncleaved.

3. "On the Cambrian (Sedgw.) and Silurian Rocks of Scandinavia." By J. E. Marr, Esq., B.A., F.G.S.

The author has examined the following areas of Cambrian and Silurian rocks in Scandinavia:—(1) Dalecarlia, (2) Ostrogothia and Westrogothia, (3) Christiania, (4) Scania, (5) Baltic Isles. A sketch of the stratigraphy of each of these regions was given, and the author gave the following conclusions:—

| | | |
|---|---|---|
| Silurian. | Mudstones of Ramsåsa and Bjersjölagård ......... | = Ludlow. |
| | *Cardiola* beds: *Cyrtograptus* and *Retiolites* Shales | = Wenlock. |
| | *Lobiferus* Shales: Upper part of Brachiopod beds | = May Hill. |
| Cambrian. | Lower part of Brachiopod beds ................ | = Upper Bala. |
| | *Trinucleus* Shales: *Beyrichii* Limestone ........ | = Middle Bala. |
| | Kärgårde Shales: Cystidean Limestone .......... | = Lower Bala. |
| | etc. | = etc. |

A correlation with the beds of Bohemia was also given. The author pointed out that there is evidence of a physical break, varying in amount, as well as of a palæontological one between the Cambrian and Silurian of Scandinavia. Several of the beds of Scandinavia admit of a very exact parallel with strata in the English Lake District.

The author considered that the fauna of the Scandinavian deposits affords evidence of migrations. This can be shown by observing that the same forms occur in two beds of different age, but are absent from an intermediate one; or by tracing beds laterally, and showing that the forms occur in an earlier deposit in one locality than in another.

The author considered the black shales deep-water deposits, and accounted for their wide extent by supposing the material derived directly from the decomposition of the felspar in metamorphic rocks, and so in a very fine state of division. The deep-water fauna in the Cambrian appears to have migrated from the south-west; the shallow-water forms, as might be expected, were more variable in their direction of migration: examples were given in support of this view. In Silurian times the direction of migration appears to have changed, the dispersal taking place from Britain, owing probably to greater local upheaval there. The coast-line also, instead of running in a W.N.W. and E.S.E. direction, seems to have run more W.S.W. to E.N.E., as shallow-water forms are common in Britain, but deep-water forms in the central Swedish area. The result of the author's investigations, as bearing on classification, is that there is a break in Scandinavia at the base of the equivalents of the May-Hill series, but no other break in the Cambrian series of Sedgwick of equal importance: no break, physical or palæontological, existing at the base of the *Ceratopyge*-limestone (Tremadoc), where some authors have drawn a boundary.

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III.—April 26, 1882.—J. W. Hulke, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On Fossil Chilostomatous Bryozoa from Mount Gambier, South Australia." By Arthur W. Waters, Esq., F.L.S., F.G.S.

The author gave a descriptive list of 66 species of Bryozoa, belonging to the suborder Chilostomata, from the collection of the Geological Society and of Mr. Etheridge, Jun.; of these, 15 were considered to be new, 28 are now found living, of which 23 in Australian seas, 25 were found in the material previously described from S.W. Victoria, 2 were considered identical with European chalk forms, 11 with Miocene, 12 with Pliocene, and 21 have been found in a collection from Bairnsdale, Gippsland.

Mr. Waters states that the collections in his hand from S.W. Victoria, Mount Gambier, and Bairnsdale will together yield about 200 species of Chilostomata and Cyclostomata.

2. "*Thamniscus*: Permian, Carboniferous, and Silurian." By George W. Shrubsole, Esq., F.G.S.

After a sketch of the genus, represented by one Permian, possibly two Carboniferous, and one Silurian species, the author discussed certain peculiarities claimed for the Permian form by the founder of the genus, Prof. King, viz. certain "denticles, vesicles, and hemispheric bodies, similar to those observed in *Cellaria salicornea.*" These the author failed to find, but observed on the cell-face of this form a strong defensive spine, hollow at the base, which, when worn, gave an appearance which resembled the above structures. A denticle-like process also seems only to be the unequal wearing down of the cell-mouth. The author redescribed the genus, as well as a new Silurian species, for which he proposes the name of *Thamniscus antiquus.* It is from the Dudley limestone, and is in the Woodwardian Collection at Cambridge. It is not rare, but is generally too fragmentary for description.

3. "On the Occurrence of a New Species of *Phyllopora* in the Permian Limestones." By George W. Shrubsole, Esq., F.G.S.

The specimen on which this species is founded is mentioned in an early paper by Prof. Sedgwick on the Magnesian Limestone. It was afterwards named *Fenestella ramosa* by Prof. Phillips, and considered by Prof. King identical with *Thamniscus dubius.* But with neither of these genera has it any relationship, as it really belongs to King's genus *Phyllopora,* founded to include certain Polyzoa formerly referred to *Retepora,* a modern genus whose characteristics cannot be detected among the remains of the Palæozoic Polyzoa. The author described the characters of the species, and traced the history of the genus, which, in its range from Lower Silurian to Permian times, is characterized by two distinct types of species.

4. "On the Relations of the Eocene and Oligocene Strata in the Hampshire Basin." By Prof. John W. Judd, F.R.S., Sec. G.S.

The section at Whitecliff Bay, in the Isle of Wight, affords us the means of determining the true order of succession of nearly 2000 feet of Tertiary strata, and is therefore employed as a standard to which to refer the strata seen in sections where the order of succession is not so clear. The author supported the views of Prof. Prestwich as to the limits of the Bracklesham series, as opposed to the opinions expressed on the subject by the Rev. O. Fisher. He pointed out the confusion which has arisen from the correlation of certain strata in the Hampshire basin with the barren Lower and Upper Bagshots of the London area, in which fossils are so rare as to render their geological age somewhat doubtful. To the Lower Bagshot some authors have referred 660 feet of the strata seen at Alum Bay; while other authors have restricted that name to about 73 feet of the same section. The age of the Upper Bagshot of the London basin is admitted by all authors to be very doubtful. The only way to avoid the confusion unavoidable from using the same names for strata, the correlation of which was so hypothetical, was to employ local names for both sets of beds. He proposed to refer to the freshwater sands below the Bracklesham and Bournemouth strata, containing a distinctive flora, as "the Studland beds," and the sands above the Barton clay by the old name of "the Headon-Hill Sands."

Above these sands are a series of clays only about 40 feet thick at Whitecliff Bay, but much thicker at Headon Hill and Hordwell Cliff. These sands and clays form the Headon group; they consist of freshwater strata with bands of limestone and lignite, but including numerous inconstant intercalations of layers containing marine shells, for the most part much dwarfed. The age of the Headon group, as shown by the fossils which it contains, is that of "the zone of *Cerithium concavum*" of continental authors.

The brackish-water Headon group is succeeded at Whitecliff Bay by nearly 100 feet of purely marine strata. These marine beds, which had been shown to rest on an eroded surface of the Headon beds, contain the remarkable fauna which had been recognized by many British and foreign geologists as that of the Lower Oligocene. Similar strata with the same fossils are found in the New Forest, at Lyndhurst, Brockenhurst, Roydon, and other points, and there also attain a considerable thickness. It was pointed out that this marine series is quite distinct from the Headon, or zone of *Cerithium concavum*, with which it had been confounded.

The author had been severely criticized for the views which he had put forward in a former paper as to the manner in which the Brockenhurst series is represented in the section at the west end of the Isle of Wight. There was much difficulty in these variable estuarine beds in correlating the beds seen in Colwell Bay with those exposed in the cliffs of Headon Hill. With several previous authors on the subject, he maintained that the great series of sandstones and limestones forming Warden Point and How Ledge are continuous with those exposed in the face of Headon Hill, and, consequently, that the marine beds of Colwell Bay overlying these limestone series are younger than the brackish-water bands interstratified with the Headon beds of Headon Hill. His critics, however, insisted that these two beds agreed with one another in such a manner that they must be regarded as parts of the same bed, separated by denudation. In opposition to this view it was pointed out that the Colwell-Bay bed is of the most inconstant character, and long before reaching Headon Hill is seen to be on the point of thinning out and disappearing altogether.

In conclusion, the author pointed out that his own interpretation of the succession and correlation of the strata in the Hampshire basin brings them into complete harmony with that which is maintained by the great majority of continental geologists, while that of his critics appeared to be hopelessly irreconcileable with their views.

## CORRESPONDENCE.

### FARTHER DISCOVERY OF MAMMOTH REMAINS AND ARCTIC SHELLS, BELOW BOULDER-CLAY, NEAR KILMARNOCK.

Sir,—In the Geological Magazine, Vol. VI. p. 525, I reported a find of Arctic shells, below 48 feet of Boulder-clay, in sinking a pit, near to the old quarry, at Greenhill, Kilmaurs, where so many Mammoth and Elk remains have been discovered. A like discovery, of a Mammoth tusk, and Arctic shells, have just been made in a bed of muddy sand, below 70 feet of surface and Boulder-clay, in sinking a pit 2½ miles west, or down the valley, from the above quarry. The tusk was broken up and destroyed, the workmen mistaking it for wood; a fragment was procured and lodged in the Hunterian Museum, Glasgow, for preservation. The shells were identified by Mr. John Young, F.G.S., of this museum, as follows:—***Astarte compressa, Cyprina Islandica, Fusus?*** a fragment, ***Mya truncata, Nucula tenuis, Tellina balthica, Natica Grœnlandica, Turritella terebra.*** Some of these, and other fragments of shells found, had a water-worn appearance. The section taken downwards is as follows:—surface and Boulder-clay 78 feet, muddy sand, the mud and sand finely laminated in alternate layers, about two feet, soft sand one foot, gravelly sand (fossiliferous) 20 feet, resting on the Carboniferous strata. This section is interesting, by throwing light upon the position, and age, of these fossiliferous beds, as well as evidence of their extent. Dr. Bryce makes them Pre-Glacial, and of the age of the Upper Crag (Quarterly Journal, vol. xxi. p. 213). From an examination of the rock specimens in the 20 feet bed of sand underlying the fossiliferous beds, they are largely made up of erratics, highland schists, gneiss, granite, Old Red Sandstone, quartz, etc. These erratics are greatly in excess in this bed of sand, to what they are in the Boulder-clay of the district, that overlies the fossiliferous beds. At one time I made a minute examination of the rocks in the Boulder-clay of this district, and found the erratics small, about 4 per cent.; but in this bed they are nearly 30 per cent. of the whole rock contents. This is certainly against the Pre-Glacial age of the beds. R. Craig.

Langside, Beith.

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## THE DISTURBANCES AT VOBSTER IN SOMERSET.

Sir,—The announcement of the discovery of Millstone Grit at Vobster, made in your last Number by the Rev. H. H. Winwood, is so interesting that I hope he will give further particulars, and publish a section of the facts observed. In my diagram-section (Geol. Mag. Vol. VIII. p. 153) I have inserted the Millstone Grit at Upper Vobster, but not at Lower Vobster (to which Mr. Winwood, I presume, refers): its presence at this latter place will simplify the explanations, and dispose of one argument against the "overthrow theory." To that theory, which supposes that the Limestone masses of Vobster were portions of rocks "squeezed together, thrown up, and finally folded over from the main ridge" (*i.e.* the Downhead Anticlinal), my chief objection is that I can discern no evidence in the structure or lie of the Lower Carboniferous rocks and Old Red Sandstone to favour the notion. Why not take into account the ascertained structure in these hard and well-marked rocks, and not rely simply on the evidence in the neighbourhood of Vobster, where in the comparatively soft and yielding Coal-measures (to quote the words of Mr. McMurtrie) "we find an amount of confusion and distortion which literally baffles description"?

We have actual evidence of a faulted-anticlinal at Penhill House, west of Binegar, the continuation of which disturbance may, and very probably does, run through the Vobster coal-district, to the north of the Downhead anticlinal: and it would be quite capable of producing the phenomena of the inverted Limestone-masses (see Geol. Mag. Decade II. Vol. III. p. 457).

My belief is, that had a diagram on a true scale (as regards the configuration of the land and the great divisions of the rocks), been attempted by those who now support the "overthrow theory," this theory would never have found an advocate. Will Mr. Winwood kindly furnish such a diagram? Horace B. Woodward.

Fakenham.

## THE GEOLOGY OF ANGLESEA.

Sir,—I do not clearly see the object of the paper by Dr. R. D. Roberts, which appears in the May Number (p. 152). It is simply a recapitulation, from his point of view, of the arguments which have already been submitted by us to your readers, with whom the matter, so far as I am concerned, must now rest. It is, perhaps, rather singular that Dr. Roberts should strive so persistently to hunt to the death an argument which was adduced by me in support of a conclusion which he himself accepts, viz. the Archæan age of the granitoid series. I must decline to adopt his views as to the mode in which I shall use my private note-book. I claim to be the best judge of what is essential or non-essential to my argument. The faulted sections have not been published, simply because they are not required. Dr. Roberts evades the difficulties which I pointed out in his reasoning on the sections at Bryngwallen and Penlon, on the pretext that he has discussed them in his dispute with Prof. Bonney. This is quite erroneous, as those who have followed the controversy can judge.

From Dr. Roberts's paper, your readers will have learned, probably not without surprise, that he sent to you his list of my "errors" at a time when he had not access to my papers, and they will know how to estimate the accuracy of a critic who can make sweeping charges against another, without taking the trouble to ascertain if he is truly representing his opponent's views. Dr. Roberts has, however, candidly apologized for one of his random assertions; and the other corrections will, I doubt not, appear in his next communication.

Wellington, Salop. C. Callaway.

## THE HEADON HILL SECTION.

Sir,—Possibly Prof. Judd's letter in the April Number may have been read by some who had not seen mine. I therefore ask you to reprint the portions to which he refers. I wrote:—

"When we recollect that one of the authors (of the paper under discussion) was born in the Isle of Wight, and spent the best years of his life in professional work, chiefly in exploring and collecting from the Eocene beds of the district, some little amount of warmth was justifiable in defending what were his own well-matured views, as well as those of the surveyors, against an attack, which, however learned, was apparently based upon work in the museum and library." "Palæontological evidence is a powerful assistant to stratigraphy, but it must yield precedence to results clearly made out in the field."

The Professor in his reply enumerates his extensive continental labours and studies, thus justifying my estimate of his learning. But it seems to me now, that his foreign studies have been carried too far. For his comment on the above quoted passage is, that he hopes I am the only geologist who will regard such action (the study of foreign geology) as constituting a disqualification on his part—an interpretation certainly "foreign" to my meaning.

O. Fisher.

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## RATE OF DENUDATION.

Sir,—The appearance in your March Number of the letter of Mr. McJames asking explanation of some points in Mr. Tylor's letter induces me to notice some errors in the latter.

1. Evidently by a slip of the pen Mr. Tylor has given $v^5$ instead of $v^6$ as the law of variation of transporting power of running water, although his calculations are based upon the true law: $v^6$. Mr. Tylor is right, therefore, in stating that, when the velocity increases 3 times, the transporting power is increased 729 *times*, and not 243 times, as Mr. McJames thinks it ought to be. This law was established by Mr. Hopkins in 1842 (Phil. Mag. 1845, vol. xxvii. p. 56), and is now universally accepted. It may be stated thus: "*The weight of the largest fragment (of given form and sp. gr.) transportable by a current varies as the sixth power of the velocity.*"

2. But *transporting* power must not be confounded with *erosive* power. This is Mr. Tylor's mistake, and it vitiates all his calculations. The resistance to be overcome in the one case is *weight*, in the other *cohesion*. The one varies as $v^6$, the other probably $v^2$. In many cases of lightly cohering material the resistance is a mixture of these two resistances and the power of removal will vary somewhere between $v^2$ and $v^6$.

Joseph Le Conte.

Berkeley, California.

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## JUKES AND THE SUPPOSED LAURENTIAN OF DONEGAL.

Sir,—I have taken advantage of the first leisure I have had to look up my notes for the "Geology of Ireland," and have to request that you will publish the following.

In 1862, after describing the Laurentians or primary gneiss of Sutherland, Jukes goes on to say:—"Ireland—It is probable that some of the highly metamorphosed rocks of the north of Ireland may consist of this Pre-Cambrian gneiss."

G. H. Kinahan.

BUTTERWORTH & HEATH SC.

Yours very truly

Andw Ramsay

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. IX.

No. VII.—JULY, 1882.

## ORIGINAL ARTICLES.

### I.—Eminent Living Geologists.—No. 5.

### Sir Andrew C. Ramsay, LL.D., F.R.S., V.P.G.S., etc., etc.

(WITH A PORTRAIT.)[1]

THE recent retirement of Sir Andrew Ramsay from the post of Director-General of the Geological Survey of Great Britain, affords us a fitting opportunity to place on record in the pages of the Geological Magazine a short account of the career of this eminent living geologist.

Andrew Crombie Ramsay was born in Glasgow in 1814, being the son of William Ramsay, a chemist of more than local distinction, the inventor of several chemical processes, such as the manufacture, on a large scale, of bichromate of potash, and of pyroligneous acid. As was naturally to be expected from such a man, he impressed upon his children his own love for science, and he cultivated in them a strong taste for literature.

It was not till Andrew was 23 years of age that his attention was drawn to geology. The science had then, under the influence of Buckland, Sedgwick, De la Beche, Phillips, Murchison, Lyell, and others, begun to take its true position, and was advancing with rapid strides. Desiring to know if there was any reality in its teachings, Mr. Ramsay commenced reading Scrope's "Volcanoes of Auvergne," and Lyell's "Principles of Geology." The future of Andrew Ramsay was thus fixed, though he had yet to labour for some time in a sphere which was uncongenial to the young and ardent lover of science. Had the British Association effected no other good, it has done great service by drawing from the crowd in which they were obscured, many a true inductive philosopher. A committee was formed in Glasgow in 1839, to prepare for the reception of that body. Mr. A. Ramsay was a member of that committee, and in this capacity the task of constructing a geological map and model of the Isle of Arran fell entirely to him. Though inexperienced, the young geologist set to work with a will; he surveyed the island, collected specimens of its rocks and minerals, mapped and modelled it on the scale of six inches to the mile. This map and model were exhibited at the Meeting of the British Association in 1840, and attracted the attention of geologists. The result was, that Mr. (afterwards Sir) Roderick Murchison asked Mr. Ramsay to accompany him to Russia, the geological examination of which country he was about to undertake at the invitation of the Emperor. The offer made was not likely to be refused by an ardent aspirant for geological honours, warmed with his first success. But in March, 1841, Ramsay having proceeded to London to join Murchison, Mr. (afterwards Sir Henry) De la Beche offered him the post of Assistant-Geologist on the Geological Survey of Great Britain; which, after due consideration, he preferred to accept. In April of that year Mr. Ramsay joined the Geological Surveyors at Tenby. Released from uncongenial city pursuits, associating with De la Beche, Professor John Phillips, and the younger members of the Geological Survey, living almost among the hills, by the rivers, and on the sea-coasts of South Wales, every day to him seemed a holiday. In this year Mr. Ramsay published his "Geology of the Isle of Arran," and geological science became the aim and object of his life. In 1844 he was elected a Fellow of the Geological Society. In 1845 the Geological Survey of Great Britain was remodelled, and Ireland was included in it. Mr. De la Beche was appointed Director-General for the United Kingdom, with two Local Directors, Mr. A. C. Ramsay being appointed Local Director for Great Britain, and Captain (afterwards Colonel Sir Henry) James the Local Director for Ireland. Sir Henry James subsequently became the head of the Ordnance Survey, and was succeeded in Ireland by Dr. Oldham, afterwards Director-General of the Geological Survey of India, who was followed by Professor Jukes. Sir Henry James, Dr. Oldham, and Professor Jukes have now all passed "into the silent land," but their names and labours will live long after them.

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[1] We are indebted to the courtesy of the publishers of the "Leisure Hour" for permission to reproduce the excellent portrait of the subject of our present Memoir. —Edit. Geol. Mag.

As Local Director of the Geological Survey of Great Britain, Ramsay was brought into contact with most of the young rising men of science, amongst whom he had, as his special friends, Edward Forbes, Lyon Playfair, Robert Hunt, A. R. C. Selwyn, and Warington Smyth, and he was fairly launched on that scientific career in which he has since won such a world-wide reputation.

In 1848 he was appointed to the Chair of Geology in University College, London, and he was elected a Fellow of the Royal Society in 1849. Professor Ramsay held this chair until 1851, when he resigned it for the Professorship of Geology in the Royal School of Mines, which was opened on the 6th of November by an inaugural discourse delivered by Sir H. De la Beche. This was followed by opening lectures from Dr. Lyon Playfair, C.B., F.R.S., Professor Edward Forbes, F.R.S., Mr. Robert Hunt, F.R.S., one from Professor Ramsay, F.R.S., "On the Science of Geology and its Application," one by Professor W. W. Smyth, M.A., and one by Dr. J. Percy, F.R.S. When the British Association met at Cheltenham in 1856, Prof. Ramsay was the President of the Geological Section, on which occasion he delivered an address "On Breaks in the Succession of the British Rocks," showing the connexion of unconformity with the changes of genera and species. In 1857 he was deputed by the Geological Society to the American Association for the Advancement of Science. Professor Ramsay then visited Canada and the Northern States in company with Sir W. Logan and Prof. James Hall, thus learning much of Laurentian and Silurian geology, and writing, on his return, a paper on the "Glacial Phenomena of North America." He also delivered a discourse at the Royal Institution on this subject.

No geologist has studied the phenomena of glacial action with more assiduity and laborious attention to the minute, as well as large indications of the action of ice, than Professor Ramsay. In 1852 he made his first journey to Switzerland, since which time he has made several, for the purpose of studying the glaciers of that country. In pursuit of this knowledge he has visited various parts of Germany and the North of Italy; he has crossed many high glacier passes, and climbed the Lysham and other mountains. At different times several memoirs and essays on this subject have appeared from the pen of Professor Ramsay. Amongst others, the "Old Glaciers of Switzerland and North Wales," which appeared in the first volume of "Peaks, Passes and Glaciers," and which was subsequently published as a separate volume by Messrs. Longman. A paper on "Permian Ice, on the Occurrence of Glaciers and Icebergs during the Permian Epoch," was the first that grappled with the subject of glacial epochs in old geological periods; some vague hints had previously existed as to the possibility of such phenomena, but the fact was proved by Professor Ramsay from the size, shape, and ice-scratches of the stones in the Permian breccias, and the great distance from whence many large boulders had been transported. Pursuing the same inquiry, Professor Ramsay published in the "Reader," notices of ice-smoothed and ice-scratched stones in a conglomerate of the Old Red Sandstone near Kirkby Lonsdale, an idea first conceived by him in 1841, and the confirmation of which he was long looking for. The previous paper, taking up an entirely new position, was treated with some indifference by the older geologists, while the novelty of the views by degrees excited some interest in the younger men. Now that, on astronomical grounds, geologists begin to admit the probability of the recurrence of glacial periods, they also begin to refer to the Permian paper by Professor Ramsay, which lay half dead for eleven years, and the time may be near when they will quote with approval the hypothesis of the recurrence of periods of cold. These enlarged generalizations from the most painstaking observations speak of a rare combination in the character of Professor Ramsay's mind. He has never been a mere geological observer, for whilst he has been unwearying in his field-labours, he has at the same time been cautiously drawing his deductions, and at length boldly enunciating views of a high philosophical character. This is strikingly shown in a much earlier paper "On the Denudation of South Wales and the Adjacent Counties of England," which appeared in the first volume of the Memoirs of the Geological Survey in 1846.

Professor Ramsay has published numerous papers, memoirs, etc., in the "Proceedings of the Geological Society," the "Philosophical Magazine," etc. His paper on "The Glacial Origin of Certain Lakes," etc. (Quart. Journ. Geol. Soc. 1862), and other memoirs on this and allied subjects, as the erosion of valleys, have attracted much attention, and excited a discussion which is still maintained with animation and interest. Professor Ramsay has published a geological map of the British Isles, and illustrated and explained it by a work "On the Physical Geology and Geography of Great Britain."[1] But the maps and sections produced, under his direction, by the Geological Survey of the United Kingdom, are the finest evidence of his labours, and of those of the band of young geologists who have been in great part trained by him. Professor Ramsay's latest work in immediate connexion with the National Survey, "The Geology of North Wales," was declared by the late Sir Roderick Murchison to be "the most important work which has been issued by the Geological Survey during the ten years that have elapsed since I became Director." Few books in the English language contain a greater amount of geological detail, almost entirely the result of actual survey by the writer. To those who desire to master the geological structure of North Wales, this work is an invaluable gift. A new edition has just been issued, embodying all the latest researches into this interesting country.

In 1864–5 Professor Ramsay was President of the Geological Society, and in 1866 the University of Edinburgh bestowed the degree of LL.D. upon this eminent geologist. In the same year he was again elected President of the Geological Section of the British Association, and delivered an Inaugural Address to that body at Nottingham.

On February 17th, 1871, the Council of the Geological Society of London awarded the Wollaston Gold Medal to Professor Ramsay.

On the death of Sir Roderick Murchison, which occurred October 22, 1871, the general care of the Geological Surveys, which had so long devolved upon Prof. Ramsay, met its due reward, and he was shortly afterwards made Director-General, Prof. E. Hull, M.A., F.R.S., being Director of the Irish Branch, and Prof. A. Geikie, LL.D., F.R.S., Director of the Geological Survey of Scotland.

On Prof. Ramsay retiring from the office of Lecturer on Geology to the Royal School of Mines, he was succeeded by Prof. J. W. Judd, F.R.S.

He was a recipient of one of the Royal Medals of the Royal Society on the 30th November, 1879.

In 1880 Prof. Ramsay was President of the British Association at Swansea, taking as the subject of his address, "The Recurrence of Certain Phenomena in Geological Time."

As President of Section C, at the Meeting of the Association at York, in 1881, Prof. Ramsay reviewed "The Origin and Progress of the Present State of British Geology, especially since the first Meeting of the British Association at York in 1831." On December

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[1] A work which has now arrived at its fifth and wholly re-written edition.

7th, 1881, the honour of Knighthood was conferred upon him in acknowledgment of his long and distinguished public services, and at the end of the year Sir Andrew Ramsay resigned his appointment as Director-General of the Geological Survey of the United Kingdom.

The present Director-General of the Geological Survey, A. Geikie, Esq., LL.D., F.R.S., has been connected with that service since Oct. 15, 1855. When the Geological Survey of Scotland was recognized as a separate branch of the establishment, Mr. Geikie was appointed as Director. In 1865, Mr. Geikie was elected a Fellow of the Royal Society of London; he was President of the Geological Section of the British Association at Dundee in 1867, and again at Edinburgh in 1871; in the same year he was created Murchison Professor at the express wish of the founder of the Chair, an appointment which he only recently resigned. In 1873, the University of Edinburgh conferred upon him the distinction of LL.D., and in 1881, the Geological Society, in recognition of his scientific labours, presented him with the Murchison Medal. Mr. Geikie is well known as an accomplished writer. Amongst his many contributions to geological literature may be mentioned, "The Story of a Boulder," 1858; "The Glacial Drift of Scotland," 1863; "The Scenery and Geology of Scotland," 1865; this was accompanied by a Geological Map of Scotland; "The Life of Murchison," 2 vols. 1874; and his lately published "Geological Sketches at Home and Abroad." He contributed the exhaustive article on Geology to the current edition of the Encyclopædia Britannica, and is now engaged in the preparation of a "Text-book of Geology," which will form a volume of some 800 pages.

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## II.—On the Mode of Origin of the Loess.

By Professor Baron F. Richthofen,
of the University of Bonn-on-the-Rhine.

[The following communication, although addressed to the Editor in the form of a letter, is of such importance that we need make no apology for treating it as an Original Article, feeling sure that our readers will be as much interested as ourselves in the observations of so eminent a geologist, who has spent many years in actual study of these vast deposits, as to the origin of which he is consequently able to speak with such profound knowledge and mature judgment. —Edit. Geol. Mag.]

Sir,—You will receive in a few days a copy of the second volume of my work on China, which I requested my publisher (Mr. Dietrich Reimer, of Berlin) to send to your address.[1] In this volume are embodied the results of my travels in *Northern* China, and it is chiefly devoted to the geology of that country. The third volume will comprise Southern China, while the fourth, which is to contain the description of a portion of the fossils collected by me, is now going through the press and will be ready within a few months. It will be accompanied by 52 plates. The palæontological memoirs

[1] Since received.—Edit. Geol. Mag.

in it have been prepared by Messrs. Dames, Kayser, Lindström, Schenk and Schwager. Unfortunately, the topographical and geological maps relating to Northern China (14 sheets), which will be published as the first portion of an Atlas of China, are not yet ready, and the second volume, to which this first series of maps belongs, must make its way for some time without their aid.

I hope that, if you should consider the book worthy of a special notice in the MAGAZINE, the reviewer will kindly take into consideration that, with the exception of the very able report of Pumpelly on a district of comparatively small extent in the vicinity of Peking, this is the first attempt towards the geological description of a vast region which, orographically as well as geologically, was entered by me as a *terra incognita*, and that as a solitary wanderer I did not enjoy the advantages offered to the geological member of a well-equipped expedition, who can devote all his energy to one single class of subjects, and is neither occupied with the construction of his own topographical maps, nor hampered by the daily-recurring care of pack-mules, carriage-bearers, etc.

The first volume of my work, which was published in 1877, has not been sent to the GEOLOGICAL MAGAZINE, because its contents were chiefly geographical and historical. One geological problem only was treated in it at considerable length; this is, the origin of the Loess and the mode of growth of the soil of steppes. It appears to me, therefore, quite natural that the book should have been taken notice of by only a few geologists. But I might have expected that a prominent scholar, who in his literary studies has moved over the same ground with me and, although with a far wider scope of learning than I acquired and at very much greater length than I was able to devote to the subject, has treated the history of Central Asia, should have at least glanced at the contents of the book. Such, however, has evidently not been done by Mr. H. H. Howorth, when he undertook to discuss the question of the origin of the Loess in two numbers of the MAGAZINE (January and February, 1882), and it appears that my publications on the subject have completely escaped his knowledge. All he knows respecting a theory on the mode of origin of the Chinese Loess, which I first advanced in 1870, is taken from the few lines of a foot-note of a paper by Mr. Kingsmill, who, in 1871, accepting the name of Loess, which I applied to the Chinese deposits, suggested a theory of a marine origin for them (Quart. Journ. Geol. Soc. vol. xxvii. pp. 376 to 383).[1] If the words in which Mr. Howorth mentions my theory did really render it, his arguments against it would, at least in part, be well founded; but I consider it not improbable that he would not have started the controversy if he had taken the trouble to make himself acquainted with the subject against which it is directed.

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[1] The theory of the subaërial origin of the Loess, which, according to Mr. Howorth (p. 16), "has received the sanction of Richthofen and Pumpelly," but which, in fact, was started by me and endorsed by M. Raph. Pumpelly (*N. Y. Nation*, April 14, 1878), who had advocated before a fluviatile origin, was noticed first very briefly in my *Letter on the provinces of Honan and Shansi*, Shanghai, 1870, pp. 9-10, and at some greater length in my *Letter on the provinces of Chili, Shansi, Shensi*, etc., Shanghai, 1872, p. 13-18. The full discussion of the subject is given in *China*, vol. i. pp. 56 to 189, and a short abstract in *Verhandlungen der K. K. geologischen Reichsanstalt*, 1878, pp. 289 to 296. I could not avoid reverting to it repeatedly in *China*, vol. ii. (see for descriptions f. i. pp. 349-351, 422-427, 530-533, 550-551, and for discussion, pp. *741 to 766).*

Will you allow me, therefore, to offer to the readers of Mr. Howorth's article a short explanation of the views at which I arrived regarding the mode of origin of the Loess when I was gazing daily at its astounding deposits and grotesque features in the Chinese provinces of Honan and Shansi, views which I found not only corroborated during my further travels throughout all Northern China and in the Mongolian Steppes, but which, on the strength of comparative study, I was afterwards able to apply with equal force to Tibet, the region of Khotan and Yarkand, and great portions of south-western Asia, as well as to all Loess-covered regions of Europe, and of the continents of North and South America.

Any theory which undertakes to deal with the problem of the origin of the Loess must give a valid explanation of the following characteristic peculiarities of it, viz.:

1st. The petrographical, stratigraphical, and faunistic difference of the Loess from all accumulations of inorganic matter which have been deposited previously and subsequently to its formation, and are preserved to this day.

2nd. The nearly perfect homogeneousness of composition and structure, which the Loess preserves throughout all the regions in which it is found on the continents of Europe and Asia; it offers in this respect a remarkable contrast to all sediments proved to be deposited from water within the last geological epochs, excepting those of the deep sea, which are here out of the question.

3rd. The independence of the distribution of the Loess from the amount of altitude above sea-level. In China it ranges from a few feet to about 8000 feet above the sea,[1] and farther west it rises probably to much greater altitudes. In Europe it is known at all elevations up to about 5000 feet, at which it occurs in the Carpathians.

4th. The peculiar shape of every large body of Loess, as it is recognized where erosion has cut gorges through it down to the underlying ground without obliterating the original features of the deposit. These are different according to the hilly or level character of the subjacent ground. In hilly regions the Loess, if little developed, fills up depressions between every pair of lower ridges, and in each of them presents a concave surface; but where it attains greater thickness, it spreads over the lower hills, and conceals the inequalities of the ground. Its concave surface extends then over the entire area separating two higher ranges, in such a manner as to make the line of profile resemble the curve that would be produced by a rope stretched loosely between the two ranges.

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[1] I met with it in China, in 1870, only at an altitude of 6000 feet, and this figure is given by Mr. Howorth (p. 76) erroneously as an observation of Mr. Kingsmill; in 1871 I found thick deposits of Loess at an elevation of 7000 feet in Southern Mongolia, and of 8000 feet on the Wu-tai-shan range in the province of Shansi.

This shape of surface is precisely similar to that which is characteristic of the salt steppes of Central Asia. It must, however, be remarked that, just as in these, the development is frequently unequal on either side of a valley, and that the preponderance of the deposit on the same (f. i. the westerly) side can sometimes be observed in each basin throughout a larger region. The lowest portion of the surface of larger basins is frequently taken up by stratified soil consisting of the finest particles of Loess, and exhibiting a strong impregnation with alkaline salts. Over table lands and plains Loess is spread in the shape of most uniform sheets.

5th. The composition of pure Loess, which is the same from whatever region specimens may be taken, extremely fine particles of hydrated silicate of alumina being the largely prevailing ingredient, while there is always present an admixture of small grains of quartz and fine laminæ of mica. It contains, besides, carbonate of lime, the segregation of which gives origin to the well-known concretions common to all deposits of Loess, and is always impregnated with alkaline salts. A yellow colouring matter caused by a ferruginous substance is never wanting.

6th. The almost exclusive occurrence of *angular* grains of quartz in the pure kinds of Loess.

7th. The complete absence of stratification. To this must be added the singular position of the laminæ of mica. When these are deposited by water, they are arranged horizontally and accumulated in separate layers, while in Loess they are distributed without any order, and occur in every possible position.

8th. The capillary structure caused by the occurrence of innumerable tubes, mostly incrustated with carbonate of lime, which have generally a vertical position, and ramify downwards like the roots of grass. Where Loess is covered by vegetation, the tubes may be seen taken up by rootlets to the depth of a foot or a few feet from the surface. In this internal structure, besides the mode of occurrence, is founded the chief difference of Loess from ordinary loam. The former may be designated as a kind of calcareous loam provided with internal structure.

9th. The tendency to vertical cleavage, which is the immediate consequence of the two last-named properties.

10th. The fact that land shells are imbedded in immense numbers throughout the Loess, and that the most delicate shells are perfectly preserved. Fresh-water shells are of extremely rare occurrence, as has been correctly pointed out by Mr. Howorth.

11th. The great quantity of bones of mammals found in the Loess, the genera and mostly the species, or the next relatives, of which are known to abound at present in steppes and on grassy plains. Herbivorous animals are represented as well as carnivorous preying on the former.

12th. The fact that wherever Loess fills a basin between hills, the inclined slopes of these are covered by angular fragments of the adjoining rock, on which the yellow soil rests. Layers of these fragments, beginning with a slight inclination and then passing into an horizontal position, extend from the hill-sides for some distance into the accumulation of the Loess itself, separating it in the neighbourhood of the encasing slopes into layers of varying thickness, while towards the central portion of each large basin this separation ceases almost completely, and the soil is very homogeneous from top to bottom, even in those instances where the vertical thickness is 1500 feet and more.

It is perfectly evident that no theory starting from the hypothesis of the deposition of Loess by water can explain all or any single one of these properties. Neither the sea nor lakes nor rivers could deposit it in altitudes of 8000 feet on hill-sides. Origin from water is perfectly unable to explain the lack of stratification, the profuse existence of capillary tubes, the vertical cleavage, the promiscuous occurrence of grains of quartz, the angular shape of these, the confused position of the laminæ of mica, the imbedding of land shells, and of bones of terrestrial mammals.

There is but one great class of agencies which can be called in aid for explaining the covering of hundreds of thousands of square miles, in little interrupted continuity, and almost irrespective of altitude, with a perfectly homogeneous soil. It is those which are founded in the energy of the motions of the atmospheric ocean which bathes alike plains and hill-tops. Too little weight has been granted hitherto by geologists to these agencies, and yet there is no other which has contributed in a greater measure to determine and to modify the character of the surface of any portion of the ground after its emergence from the sea, and to predestinate wide regions for the existence of certain kinds of plants and animals, and for the modes of nomadic or agricultural life of mankind.

Wherever dust is carried away by wind from a dry place, and deposited on a spot which is covered by vegetation, it finds a resting-place, and may be washed off and carried farther away by the next rain, if the ground is sloping, or it may be joined to the soil if the ground is flat or slightly inclined. If these depositions are repeated, the soil will gradually grow. At the same depth, therefore, to which the deepest rootlets of the grass of to-day are descending, the soil may have had its surface centuries ago. Remains of the past, such as buildings and entire cities, may in this way have been entombed by dust, provided that plants were growing on its deposits, and could secure a resting-place to all further supplies of atmospheric sediment.

In regions where the rains are equally distributed through the year, little dust is formed, and the rate of growth of the soil covered with vegetation will be exceedingly small. But where a dry season alternates with a rainy season, the amount of dust which is put in motion and distributed through atmospheric agency can reach enormous proportions, as is witnessed by the dust storms which in Central Asia and Northern China eclipse the sun for days in succession. A fine yellow sediment of measurable thickness is deposited after every storm over large extents of country. Where this dust falls on barren ground, it is carried away by the next wind; but where it falls on vegetation, its migration is stopped.

In rainless deserts the wind will gradually remove every particle of fine-grained matter from the soil, though a new supply of this may constantly be provided by the action of sandblast. The sediments of desiccated lakes, the soil which is laid bare by the retiring of the sea, the materials which are carried down by periodical torrents from glaciated regions to desert depressions, the particles which on every free surface of rock are loosened by constant decay—all these will be turned over again and again by the wind, and undergo an incessant sifting, until every earthy grain is blown off and nothing but moving sand and wind-worn pebbles remain.

The dust may travel great distances, and if the wind during the dry portion of the year blows constantly in one direction, that distance will increase, while the deposition of æolian sediments will be cumulative in places situated in the same direction. If the dust is deposited on mountain ranges endowed with considerable fall of rain and drainage towards the sea, it will be finally carried to this reservoir.

There are, however, chiefly two great classes of places where the dust of continents will rest permanently, and continue to accumulate through ages.

The first are what may be termed the central regions of continents, that is, those regions where, notwithstanding some rain which chiefly falls in one season of the year, the water has no drainage towards the sea, but is collected in inland basins from which it evaporates. This is the case in the Great Basin of North America, in Persia, and in Central Asia, from the Pamir to the Khingan range, and from the Himalaya to the Altai. The prevailing vegetation, independently of altitude, is that of the salt steppe. Grass and herbs take hold of the dust, whilst the debris that collects slowly on the hill-sides is, by very slow gradations, washed down the slopes by occasional rains, and will, if there happens to occur a period of heavier rainfall, be spread over a portion of the surface of the steppe, giving rise again to the growth of vegetation, which in its turn takes hold of the falling dust. In this way the dust will accumulate slowly but constantly through ages on those portions of the surface which are covered by vegetation. In the course of time it may reach a thickness of hundreds and perhaps of thousands of feet. The salts resulting from the decomposition of the rocks, and carried partly through the air together with the dust, and partly by water down the hill-sides, will remain in the soil, and collect chiefly in salt pools situated in the lowest portions of each basin, where, at the same time, stratified soil is deposited. As the surface which bears the vegetation is by slow degrees rising to a higher level, the tubes in the soil which contained the roots of former generations will retain their shape. The land-shells which feed on the steppe and withdraw to some depth underneath the surface in seasons of drought or cold will be entombed where they die, and the most delicate shells will be preserved. The same will be the case with the bones of mammals and birds living on the steppe, the dryness of the climate preventing the decay of any organic matter, as well as the formation of vegetable mould, which would be created in a moist climate through the decay of the organic matter.

In this way the deepest valleys, the wildest gorges, and the largest depressions in undrained regions may be gradually filled up with the deposits of dust, interchanging near the encasing slopes with the angular debris of rocks, but increasing in homogeneousness of composition and structure, and in freedom from any foreign ingredients towards the central portions of each basin. The inequalities of the ground will disappear, the lower hills will be buried, and the surface of the steppe will have a trough-like shape between every two protruding rocky ranges. If then, in consequence of a lasting change of climate, such a basin should gradually be filled with water, and an outward drainage be opened, erosion would soon furrow deep channels through the earthy deposit and expose its interior structure; the fine tubes marking the site of the roots of countless generations of plants, the remains of the shells that had fed on the grass, and the bones of the mammals that have lived on the steppe would become visible; and the earth so exposed would be what is called Loess.

Such was the line of argument which I founded on the study of the Chinese Loess. I concluded that the same regions where the traveller of the present day moves between stupendous walls of yellow earth, and gazes with daily renewed wonder at the fantastic shape of rocks of earth produced by erosion; where millions of people live in caves dug in the vertical faces of the Loess, while on its terraced surface they cultivate fields which are highly productive in wet summers, and terribly barren when moisture is not supplied in sufficient quantity—that these same regions, through which the Yellow River and its tributaries now take their courses, were once covered with dreary steppes only fit for nomadic life, and had no drainage towards the sea.

I had soon an opportunity of verifying the theory by a visit to Mongolia, where I saw precisely what my experience in the Loess regions had caused me to expect, namely, the very same shape of surface which I had observed in these, a steppe vegetation growing upon an impalpably fine earth mixed with grains of sand, and accumulations of the debris of rocks at the foot of the hill-sides. But in no place could I see the inner structure of the soil exposed to view. Proceeding, however, to the boundaries of the undrained region, where the drainage of some marginal basins had begun, but the channels of erosion were still shallow, the first sure signs of true Loess made their appearance on the side of every natural cut in the ground. From this first stage of the conversion of steppe basins into Loess basins, all grades of passage to the wildest and most grotesque landscapes, where the Loess was exposed to view in a thickness of a thousand feet, could be observed in rapid succession.

It appears to me that the theory answers all requirements as regards the Chinese Loess, in so far as it easily explains all its properties and every incident in the mode of its occurrence. It combines, moreover, into one class of natural processes two kinds of phenomena, which, although they are almost the reverse of each other in regard to their outward appearance and the conditions they afford to human existence, are closely allied in nature in respect to their geographical distribution. It need only be noticed that the salt steppes of Central Asia are surrounded on all sides by Loess regions. The chief difficulty, when the theory was first advanced, was the want of a sufficient source whence the enormous amounts of dust required by it could have had their origin. But the problem has since been resolved in a most ingenious and, as I believe, satisfactory way by Mr. Raphael Pumpelly.[1]

There exist, besides the undrained salt steppe, regions of a somewhat different kind, which serve as permanent resting-places to the subaërially deposited dust. They are sufficiently distinct from the former class of places of deposition to be styled a second class of these, although, as a matter of course, there must be a series of gradations connecting both. To this second class belong those wide grass-covered plains which are known by the names of prairies, savannas, llanos, pampas, steppes of Southern Russia and Siberia, etc. They, too, are subjected to the alternation of a dry and a wet season. They are distinguished from the drainless salt steppe by their level surface and by the fact that they are crossed and partly drained by larger rivers, the origin of which lies almost exclusively beyond their boundaries. Some of these regions are very moist in the wet season, and bear a luxuriant vegetation of grass and flowering herbs, but dry up completely during the rest of the year. The rate at which the growth of soil takes place will depend upon the character of the adjoining regions from which the winds prevailing in the dry season remove the loose soil. It can no longer be doubted that the "black earth" of Southern Russia is growing in this way, and I am inclined to the same opinion with regard to the "Regur" of India. The black colour, which is proper to the uppermost layer only, appears to result solely from the formation of vegetable mould, the deeper portions showing the brown colour of the Loess, together with its structure, although this appears to be less perfect than in the former case. The bones of mammals will probably be badly preserved in this soil, because, in consequence of the ample rains and the slow rate at which the soil grows, they will partly decay before being perfectly covered up. This may not necessarily apply to those land shells, the animals of which die underground, at their places of refuge.

Another difference from the steppes of the first class must be produced by the circumstance that the salts will be removed, in part, by the water which percolates the soil and takes its way to the river channels.

When, after my return to Europe, I commenced to study more closely than I had done in former time the Loess of this continent, its perfect similarity in regard to composition, structure, and mode of occurrence with that of Asia, could not fail to strike me forcibly, and led me irresistibly to the conclusion that it must have been

[1] Amer. Journ. of Science and Arts, vol. xvii. 1879, p. 133.

formed by the same process of long-continued subaërial deposition of dust on steppes as that of the eastern continent, and the arguments which I had applied to this appeared to me to be no less valid for the Loess regions of North and South America.

The Loess-covered portions of Europe extend, as is well known, from the Pyrenees, the Alps, and the Balkan in the south to Belgium, the North German plains and Poland in the north, and from southern France in the west to beyond the limits of the continent in the east. Every portion of this entire region must have had the character of a steppe during a sufficient length of time to allow the deposit to be formed in at least such thickness as we observe at present. This thickness increases on an average as we proceed from north-west to south-east. It appears that, while east of the Alps the beginning of the steppe era may have been of earlier date, it commenced in Galicia, Germany and France during, or shortly after, the time of most extensive glaciation, and that one or the other kind of steppe was formed on the ground of the moraines as they were gradually laid bare by the retiring of the lowland glaciers. When Europe had its north-western limit beyond the present bathymetrical line of one hundred fathoms, and the summit line of the Alps was at greater elevation than at present, a continental climate must have prevailed such as is the prime condition for the formation of steppes, and it is probable that these had then their widest extent in a north-westerly direction. It would lead me too far now to explain why it appears that the conditions of climate, vegetation and animal life prevailing north of the Alps, after having gone through a stage resembling that of the tundras, must have been intermediate in character between those existing at the present time in Siberia and those prevailing in Southern Russia, while various evidence goes to show that farther south-east, in the Hungarian and Roumanian basins, there was no drainage to the sea, and the steppes of these countries resembled those of the drainless regions of Asia.

Gradually, when, with the renewed intrusion of the sea upon the land, the continental climate of Central Europe was converted into an oceanic climate, the change progressing slowly in the direction from north-west to south-east, the growth of the Loess ceased in the north-west, while it still continued in the south-east. Even now the soil is growing where it is covered by vegetation and sheltered from erosion. But the process is extremely slow and, with the exception of Southern Russia, is no longer regional, places of subaërial deposition being scattered among others of erosion.

At the same time when I published these arguments regarding the mode of origin of the Loess of Europe, Dr. Nehring, of Wolfenbüttel, came in the course of his admirable researches on the bones found in the Loess of Northern Germany to the well-known result, that the mammals which lived there at the time of the formation of that earth were identical with, or nearly related to, those which are living now on the steppes of Arctic regions, as well as in Siberia and Central Asia, and he concluded, that Germany must then have had the character of a steppe, and been subjected to a climate similar to that which prevails at present in western Siberia.

Thus, Dr. Nehring, who, at that time, had no knowledge of my researches, was led through the study of the fossil remains to precisely the same conclusion regarding a limited region in Europe, at which I had arrived with respect to a large portion of the continent by arguing on the structure and mode of occurrence of the Loess. Since then, the continued studies of the bones of mammals contained in the Loess, which have been made by Dr. Nehring and others, have yielded an overwhelming amount of evidence in the same direction, and have enabled us to extend the first conclusions to the whole of Germany, including the Rhine valley, Bohemia, and the vicinity of Vienna, and also to Hungary.

I believe I am correct in stating that, among those who have had extensive experience in Loess regions, all who have pronounced an opinion of late years are agreed that subaërial deposition is the only mode of origin by which all its peculiar features can be easily explained. Besides Mr. Raphael Pumpelly, who knows the Loess of Asia and North America, I mention chiefly Dr. Emil Tietze, of Vienna,[1] who studied it in Persia and Galicia, and the late Professor Karl Peters, of Gratz, who has probably examined a greater extent of European Loess regions than any other geologist, and, like Pumpelly, had, previous to 1877, advocated an aqueous origin as strongly as he afterwards did the subaërial. The celebrated M. von Middendorff has lately changed his views in a similar way.[2]

According to the subaërial theory as here pointed out, two different climatic stages are required for the formation of the typical Loess regions, the first of them marked by a continental and generally dry climate, during which the soil accumulated, the other distinguished by an increase in the fall of rain, in consequence of which the soil was furrowed by the erosive power of water and the steppe basins were converted into Loess basins. It is obvious that the conditions afforded for the existence of plants and animals and for the mode of life of mankind must have been almost the reverse of each other in either of the two stages, and that their change in time corresponded exactly to their change in space, as witnessed at present by the traveller when he descends from the Mongolian salt steppes with their uniform vegetation, their animals peculiarly adapted to a roving kind of life and their nomadic and unagricultural people, to the Loess basins of China, the characteristic feature of which consists in the labyrinthic ramification of very narrow gulches cut in the yellow soil to very great depth and with perfectly vertical faces. It is this character of surface, together with the fact of the existence of a drainage at low level and the removal, by it, of the soluble salts, which causes the remarkable contrast between the features of Northern China and those of Mongolia. Vegetation offers there a far greater variety of forms; those animals which are accustomed to roving on the boundless steppe cannot exist where the greatest possible unevenness of the soil is the distinctive mark; and man is simply forced to adopt in the Chinese Loess regions a settled and agricultural mode of life, drained Loess being of all kinds of soil best adapted for the cultivation of cereals, while the innumerable recesses and naturally fortified positions afford him shelter and safety.

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[1] Jahrbuch der K. K. geolog. Reichsanstalt in Wien, 1877, pp. 341-371: and more fully explained in the same journal for 1882, pp. 111-149. This last notice, which is of great importance, came to my knowledge after writing the present article.

[2] Mém. de l'Acad. Imp. des Sc. de St. Pétersbourg, t. xxix. 1881. It appears that Mr. W. T. Blauford has also adopted the theory of the subaërial origin of the deposits filling up undrained inland basins (see Proceed. R. Geogr. Soc. 1881, p. 79), and Mr. Clarence King informs me by letter that he ardently advocates the same mode of origin regarding the Loess regions of the Mississippi basin.

It seems hardly necessary to observe, how important, on account of this mode of origin, the occurrence of Loess is to the study of the causes of the present distribution of plants and animals. The peculiar climatic conditions prevailing during the time of its accumulation. and the physical features of the regions covered by it must have influenced migration and variation in a considerable measure, and it is far from improbable that the habits of life and the migrations of primitive man over large portions of Europe and Asia have been directed by the same causes. It must be added that a slight deterioration of the climate is sufficient to change the steppe, and chiefly the drainless salt steppe, into the most arid desert, and to cause the emigration of man and animals.

I have given this *exposé* a greater length than I intended. It will refute, without any further discussion, the objections which Mr. Howorth has raised against the theory of the subaërial origin of the Loess, as, *e.g.*: that subaërial deposits such as this are nowhere being formed now (p. 16);—that it is incredible that subaërial deposits should have been deposited at a height of 6000 feet and to the depth of 1000 feet (p. 76);—that the subaërial theory treats the problem as a local Chinese problem, while it ignores that the Loess has to be accounted for in Europe as well as in China (p. 76);—that it cannot be understood how shells and animal debris could be carried by the wind (p. 76);—that the means would be inadequate to the end, as clay would not be acted upon by the wind (p. 77, after Kingsmill);—that the chemical composition of the Loess does not correspond with that of the inorganic elements of plants growing on its surface;—that there is no known means by which these inorganic matters could have been supplied from the atmosphere;—that, although silica might have been conveyed by the medium of dust storms, no way can be seen how the silicate of alumina could be conveyed;—that there is no evidence of the ramifying tubes having their origin in the roots of plants;—that the Loess is devoid of organic substances;—that Loess, if subaërially deposited, should be different in composition according to the subjacent rock and could not be equal everywhere.

After having attempted to set aside, on these grounds, the theory of the subaërial origin of the Loess, which, evidently, was known to him by name only, but never by the arguments on which it rests, Mr. Howorth proceeds to expose his own hypothesis. Like that of his predecessor Dr. Hibbert Ware, of 1832,[1] it is boldly founded on the supposition of cataclysmic events of tremendous magnitude. But while Dr. Hibbert, who had with regard to the occurrence of the Loess the limited knowledge of his time, was satisfied with one event, namely a great flood, Mr. Howorth, to whom the whole amount of the present knowledge of the subject was accessible, presupposes two stages. The first was marked by a vast volcanic outpouring of "subterranean mud," while in the second this mud was "largely steeped in floods of water," and "mixed with the ingredients of the superficial bed over which it poured." The mud was thereby spread over large extents of country, mammals and shells were imbedded in it, and the entire mass was deposited without stratification, although the flood must have reached up to at least 5000 feet in Central Europe, and to 8000 feet in China, overwhelming, as must be supposed, almost the whole extent of two continents. A similar event should have drowned simultaneously the two American continents and annihilated almost all beings living above the level of the sea. Granted, however, the flood, it is by no means easy to understand its character, as its author is opposed to the aqueous origin of the Loess, whether it be marine, or lacustrine, or fluviatile. It might be supposed that the flood consisted altogether of erupted mud, but we are not told why it did not leave a homogeneous sheet spread over the entire continent up to a few thousand feet, nor how it happened that the deposits we do find from this supposed flood occur in those regions only where the conditions of a continental climate have prevailed and do, in the greatest part, prevail to this day; nor do we learn the reasons why the Loess differs completely in composition and structure from all known kinds of volcanic mud ancient or modern, or how it is that the supposed fissures from which the enormous masses of muddy volcanic rock poured forth were rent at very great distance from the regions of the main distribution of the Loess, and at a time when volcanic energy, which had been most violent in the Tertiary age, was (at least in the regions in question) in its very last and dying stage.

I do not believe that any geologist will seriously take the trouble to argue against these fanciful views. It is strange that the same deposit which bears testimony in itself of having been formed in the slowest, the most quiet and undisturbed manner that can be imagined, should be considered the product of events grander and more violent in character than any heretofore devised in the long history of unfounded geological speculation. Whoever undertakes to advance a theory on a geological subject, should first observe, and observe again, and then compare his own results with what has been observed by others in other parts of the world. If the author of the volcanic theory of the Loess had devoted the same admirable industry, with which he has studied and written the history of the Mongols, to the personal observation of the soil on which the wanderings and warfare of that people did very prevailingly take place, and which from their original seat in Central Asia and their imperial city of Khanbaligh spread to the west of Europe; if he had, besides, taken the trouble to make himself acquainted with the arguments of the existing theories respecting the mode of origin of this soil before undertaking to put them aside; and if he had for a moment considered from a geological point of view a few of the concomitant circumstances required by his own theory, he would hardly have ventured to adopt views which could be pronounced at an early and rather low stage of geological science, but are long since abandoned, and he would never have added to them suppositions which bear the character of the infancy of that science. If there is any subject to which the theory of Mr. Howorth may be applied, it is, in a figurative way, the history of the Mongols. The crowds in which they appear suddenly on the stage resembles the outpouring of volcanic matter from a hidden source, and the flood of them which soon inundated immense regions, "mixed with the ingredients over which it poured," may indeed be compared to the action of a sweeping wave. But the laws which govern the movements of mankind have but a very distant relation to those which can be discerned in the changes of the physical conditions of the surface of the globe. F. BARON RICHTHOFEN.

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[1] This theory was noticed in *China*, vol. i. p. 162.

BONN, *May*, 1882.

## III.—TRACES OF A GREAT POST-GLACIAL FLOOD.

### 3. THE EVIDENCE OF THE VALLEY TERRACES.

By H. H. HOWORTH, F.S.A.

THE Terraces which are so conspicuous in many valleys of Western Europe, and have been largely studied in France and Britain, have given rise to a great deal of discussion. The polemics which they have suggested have been not merely about details, but about fundamental principles, and it is these fundamental principles which are still unsettled and awaiting a solution. In England at all events it may be said that every solution which is current, and there are many, fails to meet the facts, and the majority of them are singularly suggestive of the dangers of Deductive methods of reasoning. So long as we start with a mere scholastic premise that Uniformity of action is the only method pursued by Nature, and having thus committed ourselves, try to bring the facts within this rigid rule, so long are we necessarily inspiring our witnesses with the answer we wish them to give us, and so long shall we experience inevitable disappointment when some obstinate fact refuses to submit to our self-imposed rule. We shall in the following examination of the problem entirely discard this a priori theological method of discussion, and lean to whatever conclusion the facts themselves impose upon us. We must necessarily begin with a somewhat elementary position.

A river as a mechanical agent performs two entirely opposite kinds of work upon its own channel. Where its fall is great and its flow rapid, it acts as a scouring agent, carving out a deeper and deeper channel. Where its fall is slight and its flow gentle, if it be in any way charged with solid materials, it performs the opposite part, namely, it deposits material in its own channel, and tends to raise it. In both cases the great mass of the products of denudation are no doubt carried seawards and deposited as a delta or otherwise; but in regard to a certain proportion, this is not so. The Rhine is a very good example of what we mean. In its upper reaches, and again in the defiles of the Seven mountains, where it is "throttled," to use an expressive Lancashire word, its rapid and boisterous course no doubt makes it a more or less potent denuding instrument. Above and below the defile just named, where its course is slow and its fall slight, it is constantly raising its own bed. and forming a kind of natural aqueduct. The conseqnence is that presently its flow is in places above the level of the surrounding country, and has to be carefully banked and dyked, and that it has at various times broken loose and found itself a fresh channel in the wide valley, a process which has been often repeated. The fact is familiar enough in the case of the Lower Rhine, and a graphic picture of its effects in the upper waters of the river may be seen in Reclus's volume on the Geography of Central Europe, recently published, Map 139. The same thing is familiar also in the case of the Lower Thames and Trent. All this is elementary enough, but the corollary which naturally follows from it is not so generally accepted, or rather is too often ignored. *A river cannot possibly do both kinds of work at the same time upon the same part of its channel.* It cannot at the same time act as a scouring agent and as a depositing one. The two kinds of work are absolutely antagonistic, and we may certainly lay it down as an Inductive Law that periods of destruction and periods of deposition cannot be contemporaneous in the same river-bed. This law seems to be very much overlooked in some of the current theories about the origin of river valleys. Professor Ramsay, in a well-known paper on the Physical History of the Valley of the Rhine (Journ. Geol. Soc. vol. xxx. p. 81, etc.), says, "There is good reason for the belief that the whole of that part of Germany *which is now the valley of the Rhine* between Basel and Mainz was once filled with Miocene strata, the precise thickness of which is to me unknown." He then goes on to argue that a thickness of from 300 to 500 feet, and probably more, has been removed by denudation. When these strata were deposited, he urges, the drainage of the country was not, as now, from south to north, but the other way, and the level of the whole country was very much lower. He then argues that a great dislocation took place, causing the upheaval of large tracts in the Alpine district, by which the whole drainage was remodelled. It was at this juncture that the Rhine as a river commenced, on Professor Ramsay's view, its history. "The upper valley of the Rhine," he says, "was at that time filled by a river of ice which, joined with others, covered the valley more than half-way from Schaffhausen to Basel, while from its western edge and end the liquid river followed its present general direction, hemmed in *between the Jura (or rather the northern continuation of the rocks of the Jura) on the south and the lower hills of the Schwartzwald that bounded the river on the north. Its level must then have been higher than now in this part of the channel.*" He again says further on that, "allowing the Miocene strata of Mainz to have attained a height of 500 feet above the level of the present plain, there may still have been a fall in the river channel on the surface of the ancient plain of more than 300 feet between Basel and Bingen, the present fall being 531 feet." He concludes that the present Rhine valley has been excavated by the present Rhine "wandering through the long inclined plain of Miocene rocks between Basel and Bingen, and thus by degrees lowering the surface level through the ordinary processes of watery erosion," and explains in this way the occurrence of the stratified banks of gravel at various levels above those of the more modern river terraces, and also the occurrence of the Loess, which he identifies as "only river mud of a comparatively ancient date, and perhaps of glacial origin," being found at many different levels on the slopes that flank the Rhine valley, from 200 feet above the river between Herholz and Ettenheim down to the level of the Rhine itself at Eltville. "As the river by degrees lowered the level of the plain, it left its finer detritus at these and many other levels." Assuredly this theory is most extraordinary in many respects, and it is not surprising that it has failed to gain acceptance. If the Rhine between Basel and Mainz is not at present an instrument of denudation, but the reverse, how can we suppose that, when its fall was little more than one-half what it is now, and its flow correspondingly slight, it should have been so, to the enormous extent of sweeping away several hundred feet of strata and carving out the wide valley through which it flows?

Again, if the gravel and Loess, which line its flanks and occur in places down to its very level, were deposited by its waters as river mud, how could the river at the same time have been doing the work of destruction?

Again, if this vast mass of Miocene strata was bodily removed by the action of the river, where is the debris? It is true that the flats of Holland are to a considerable extent delta deposits; but they are much too small to account for the vast mass of materials that should somewhere be forthcoming. Again, how is it that in these delta deposits in Holland or in the Loess itself we should find nothing pointing to their having been the products of denudation of Miocene strata? We should assuredly have found abundant evidence of Miocene life in a rolled and broken condition both in the Loess and in the superficial deposits of Holland, if this had been so; but nowhere is this the case.

On the other hand, as we claim to have shown in a previous paper, the Loess is in no sense a river deposit. In structure, contents, and disposition its origin is most clearly marked as being other than fluviatile, and the suggestion that it is so, could hardly have been made if it had been remembered that the Loess is not merely found in the valley of the Rhine, but over a much wider area independent of the drainage of the country. Again, Professor Ramsay speaks of the Rhine at first occupying the whole valley from the Jura to the Black Forest, without explaining how such a gigantic river could have existed at all in this part of Europe. What area did it drain, whence did it derive its supply of water? Unless the whole of the water-shed were entirely different, and on a vastly different scale, it is incredible whence such a volume of water as would be required to fill the whole breadth of the Rhine valley between its limiting buttresses of mountain could have been derived; but there are other and more direct objections against the theory, which have been formulated by Sir Charles Lyell, Mr. Belt, and others. Mr. Belt has brought a number of these objections to a focus, and it will not be inopportune to quote what he says, which is mainly based on Lyell's own inductions. He says, "The Loess rests on previously deposited beds of gravel. At Wurzberg this gravel lies at only a slight elevation above the level of the river, and Dr. Sandberger informed me that it goes down to at least 50 feet below it. Here then the valley must have been excavated below its present depth to allow of the deposition of the gravel which preceded that of the Loess. Near Basel the older gravel rests directly against the steep slopes of the rocks bounding the valley, proving again that the latter had been excavated long before the deposition of the Loess commenced. At Mosbach the gravels, containing an older fauna than that of the Loess, though above the level of the river, are yet several hundred feet below the altitude the Loess attains to." The continuity and distribution of the Terraces point the same moral. Formerly it was supposed that the Upper and Lower Terraces differed in contents and in age; but assuredly Mr. Tylor's most exhaustive researches showed this view to be untenable. He seems to me to have proved that in texture and in contents (shells, bones, and palæolithic implements) the Terraces belong to precisely the same geological horizon. He has shown, I think, in the case of the Valley of the Somme, tha there are not two valley terraces of distinct age, the upper on being older than the lower, but that the deposits are continuou "on gradual slopes from the higher to the lower levels in th valley, except in rare cases or isolated spots, where the continuit is interrupted or prevented by some outstanding piece of the origina rock out of which the valley had been originally cut, in whicl case the gravel wraps round the base of the upstanding knoll o chalk."

Two of the conclusions which he urges, and which I think ar irrefragable, are—

"1. That the surface of the chalk in the valley of the Somme ha assumed its present form prior to the deposition of any of the grave or Loess now to be seen there, and in this respect corresponds witl all other valleys in which Quaternary deposits of this character ar met with.

"2. That the whole of the Amiens valley gravel is of one formatio d of similar mineral character and contains nearly similar organic ntents, the La Neuville Moulien and St. Acheul gravels being the same age, and capped with a covering of Loess also of one ;e and mineral character, the whole deposit being of a date not uch antecedent to the historical period" (Journ. Geol. Soc. vol. ɾiv. pp. 104-5).

In every way the position urged by Professor Ramsay is viewed seems to fail to explain the facts, and I doubt if any one is to be und who would now support it. Lyell's own words may best ım up what seems the inevitable conclusion, "The main body of e Loess . . . . . in the valley of the Rhine, as in the case of the ısin of the Somme, was deposited in a wide and deep *pre-existing* ısin or strath, bounded by lofty mountain chains such as the Black ɔrest, Vosges and Odenwald" (Antiquity of Man, p. 378). What true of the Rhine is true of the other river valleys of Western urope, notably the Seine, the Somme, and the Thames. The same ass of evidence is forthcoming in all these cases which makes it most if not universally accepted now that the carving out of the ılleys through which these rivers pass, however effected, was not ɪntemporaneous with, but antecedent to, the deposition in them the various superficial deposits containing the remains of the ammoth and his companions.

Having disposed of this cardinal factor in the problem, we must ɔw turn to another. Lyell, in affirming that the valley of the hine had been carved out before the deposition of the Loess, went ı to urge that the deposits of Loess occurring on its flanks at a ɪnsiderable height show that, after it had been carved out, the ılley was once more filled up with Loess to that height, and that hat remains is the undenuded edge on either side of a vast mass of oess, the rest of which has been worn down by the river. This is ɔparently the view held by Professor Prestwich in regard to the rraced gravels and loams of the other French rivers and of the hames Valley. The position is well stated by Lyell himself:

"The position of the Loess between Basle and Bonn is such as to ıply that the great valley of the Rhine had already acquired its ·esent shape and in some places, perhaps, more than its actual depth ıd width, *previously to the time when it was gradually filled up to a* ·*eat extent with fine loam. The greater part of this loam has been nce removed, so that a fringe only of the deposit is now left on the ınks of the boundary hills or occasionally some outliers in the middle the great plain of the Rhine where it expands in width*" (Antiquity Man, p. 374).

In regard to this theory, and others like it, involving gigantic ɜnudation as a postulate, I cannot avoid saying that they put a strain ɔon our credulity in a way which is rather trying. It is the shion now to suppose that we can make any demands upon Eternity e please, and invoke the operation of any cause, however stupend- ıs in its operation, if we only grant that the work was done *slowly.* e consequently have a perpetual appeal made to millions of years, d to denudations of thousands of feet, as jauntily as if it were not in many cases really hiding our want of a good reason behind a pseudo-scientific instead of a theological *deus ex machina*, which imposes just as great a feeling of awe, nay almost of consternation, upon the crowd as the older and now discredited appeal. Assuredly, it is a foolish thing to shrink from any postulate, however vast, when it is the only one that explains the facts; but just as certainly is it the best course in such discussions as these to invoke the simplest, and to discard the most complicated machinery for doing any work which we have to explain. Take the present case. We are to believe that rivers which at the present moment, except at certain critical points, are not excavating their channels, but are actually raising them by the deposition of material along their courses, have, when they flowed much higher than at present, and when therefore their currents were much slower and less destructive, swept out and scoured enormous valleys once filled up to several hundred feet with loams and gravels, etc., which same loams and gravels were, according to the same authors, deposited in these very valleys by the same rivers. How is the mechanical problem to be solved at all in this fashion?

Again, where has all the material gone? Where are the deltas at the mouth of the Somme and the Seine whose gigantic size would at once explain where all this material has disappeared to? Assuredly these are very proper questions to put, but they are not all. In the midst of the Rhine valley, near Freiburg, is the well-known volcanic pyramid called the Kaizerstuhl, which is covered with Loess. How came this there? how is it that it was not swept away (for it is largely composed of pumice and ashes), when the river was carving out the Rhine valley? and even if its volcanic nucleus was able to resist the water, how comes it that the soft mantle of Loess enveloping its flanks was not torn off? for it will be noted that such an obstacle as this mountain, standing in the midst of the river, would offer a tremendous buttress to its waters and be swept clean of all loose materials. What is true of the Kaizerstuhl is true of other old volcanos in this district, of which Mr. Belt pertinently says:—"The most ardent advocate of the theory that the Loess has been left by the river while it ran at higher levels will not, I think, suggest that the volcanic cones have been carved out by it, and yet excepting on that supposition their theory falls to the ground" (*op. cit.* p. 80).

Again, as a matter of mere mechanics, the question presents a series of difficulties. If the valleys were filled up to the height of the upper terraces with loam, gravel, etc., and the river, flowing on the top of this, occupied the whole breadth of the valley, and was, consequently, much more full of water than at present, whence did the supply of water come? what are the meteorological conditions which would induce such a flow from such a restricted watershed? It is said that the upper parts of the valleys were then filled with glaciers, and that ice was very abundant, and was in fact a great agent in twisting the beds of soft deposit and in moving the large stones which occur in these beds. With such conditions, how were the *Ficus carica* and the Hippopotamus, etc., to live? But granting the existence of such glaciers, they would not suffice to furnish such a volume of water as would fill the wide valleys from one limit to the other. If, on the other hand, the rivers, as they are, scooped out the valleys by a continuous process of denudation, we are landed on the horns of a dilemma. In the first place, they are not now destructive of their beds, but conservative; and suppose we could postulate the contradictory postulate, that a conservative river would become destructive when flowing at a higher level, we cannot conceive how a river which has scooped out a furrow in a wide valley through which it flows can break through its banks, and cut another furrow elsewhere, until it has ploughed the whole valley. Rivers that change their channels are those which, like the Yellow River, deposit largely in their own beds, and raise themselves above the level of the surrounding country. Those which run in a furrow cannot overleap their own channels.

In the forty-fifth volume of Silliman's Journal, second series, is a valuable paper by Dr. E. Andrews, of Chicago, on the deposits in the Somme valley, etc. Although I cannot agree in the use he makes of ice in explaining these deposits, I am anxious to quote the following paragraph, as stating the case well against those who urge that the river terraces are merely the fringes of a former continuous deposit. He says: "The valley of the Somme is over a mile and a half at the top, while the present river does not appear to exceed fifty feet in breadth. It is safe to say that the present stream, spread over the whole valley, would not be half an inch deep, and, making all probable allowance for spring floods, it is wholly inadequate to the production of gravel beds containing pebbles larger than a man's head, and boulders weighing a ton. This valley presents none of the characteristics of those which are widened by the meandering of a shifting narrow stream, now widening this bank and now that. It is broad, level floored, and parallel banked" (*op. cit.* p. 184). In every way the problem is viewed Sir Charles Lyell's solution of its difficulties seems to fail.

We have reached this point, therefore, that the valley terraces are not the *debris* of denudation left by the present rivers, either in carving out the present valleys from their original matrix, or in recarving them after they had, as Lyell and others suppose, and as we believe without due warrant, been refilled with soft deposits.

*(To be continued.)*

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## IV.—SUPPLEMENT TO A CHAPTER IN THE HISTORY OF METEORITES.

By WALTER FLIGHT. D.Sc., F.G.S.

(*Continued from* p. 219.)

### 1877, December 26th, 8 a.m.—Between Höhr and Ballendar, near Coblentz.

A correspondent of the "Coblenzer Zeitung," dating from "Höhr, 27th December," writes that on the preceding day two meteorites fell near the road leading to the former frontier, in the direction of Ballendar, and that the fall was attended by a very characteristic explosion. The editor of the above journal has been unable to gather any further particulars of the occurrence beyond the fact that the stones fell in a wood, and could not be discovered.

### 1877.—Casey County, Georgia.[1]

A fragment of this iron in the Vienna Collection is stated by the writer to exhibit broad and very regular Widmanstättian figures. The beam-iron averages 2 mm. across; this iron is almost exclusively developed, with unusually sharp lines of etching. Band and interstitial iron are only present in traces, and schreibersite and troilite are not recognizable.

### 1878, July 15th, 2·45 p.m.—Tieschitz, in Moldavia.[2]

A stone fell at this date, with the usual accompanying noise, within 100 paces of some people whose attention was directed by a child four years of age to a small dark cloud, from which a peculiar and increasing noise proceeded. This cloud was suddenly seen to become incandescent, but in no very high degree, and the noise became still more intense when a body was seen to fall from the cloud. The stone was warm when found. The noise was heard about the neighbourhood two miles around. The stone was secured and sent on the 29th to the Museum of the Technical High School, of Brünn. The meteor appears to have passed over Daubrawic and Sloup, and the path to have been directed from azimuth 108, altitude 40°, or from an apparent radiant in R.A. 68°, N. declination 40°.

One stone only was found, and all search for other specimens of the fall was in vain. The stone weighs 27·5 kilogrammes, and has the form of an irregular pyramid with an almost square base.

The entire surface is covered with a black crust, in places of about the thickness of that covering the stones which fell at Pultusk; on the large convex side, which is called the "breast-side," it is much thinner, and exhibits a radiated character. On the back it is thicker and rougher, and without a trace of the radiated structure. The "breast-side" is free from all great depressions, while the others show them, due probably in part to the original form of the stone, partly to the action of currents of air on the melting surface. The freshly broken surface of the stone is dull ash-grey in hue, darker than the Pultusk stones, the texture finer and more sharply marked than in the case of most of the chondrites. We see many small dull grey or dark-coloured chondra, and splinters and fragments of the same kind, many larger dull grey chondra, also white small chondra and white fragments, the latter far fewer than the former. Between them an ash-grey earthy matrix, and very few yellow metallic lustrous particles. Most of the dark chondra are less than 1 mm. in diameter, those which have a diameter of 1 mm. are fewer, and there are occasional chondra which exceed 1 mm. in size; the largest one had a diameter of 5 mm.

[1] A. Brezina, *Sitzber. Akad. Wiss.* 1880, lxxxii. Oct. part.

[2] *Denkschrifte der math. Naturwissenschaften-Classe, Akad. der Wissenschaften,* Wien. xxxix. November 21, 1878.

The microscopic examination of sections of this meteorite displayed many curious features, and appears to confirm the views already expressed by Professor Tschermak regarding the probable influences which have taken part in the form which the chondra and other inclosures take.

Some chondra presented an appearance which has not hitherto been observed. They have round depressions, which point to a plasticity of the chondra during contact, as if the spherules which form the splintered fragments had acquired their form during the act of rubbing. Others again have projections of a rounded form, or an almost pointed end. These chondra are the result of volcanic eruptions or explosion.

*Olivine.*—Both in the matrix, and in many chondra, well-developed crystals of olivine were met with. They have the same crystalline form as the olivine in basalt. Many of the chondra consist of individual crystals. Many crystals have cavities inclosing black angular grains, or a black impregnation of the crust, or black slightly translucent spherules or inclosures of "glass"; some exhibit a most distinct surface of the inclosed material.

*Bronzite.*—Barred and fibrous individuals of a brown colour are regarded as bronzite. Some of the barred chondra shown in the plate accompanying the paper of Makowsky and Tschermak are very perfectly developed and very curious. Some have a darker border, others a lighter rim. In these chondra also the inclosed material already referred to is met with.

*Enstatite.*—Many of the chondra of this mineral are distinguished by their marked foliated structure, and specimens of such are shown in the plate. Enclosed "glass" is also found in them. Many spherules, and fragments of spherules, of a crystallized mixture of bronzite and olivine or of enstatite and olivine, were noticed, none however of a crystallized mixture of bronzite and enstatite, and it appears therefore as if this meteoric tuff originated from two sorts of stony mixtures.

*Augite.*—A few small chondra with a compact pale-coloured crust have a texture and colour which differs from all the foregoing. The entire spherule is shown by polarized light to be one individual; the crust is almost colourless, the interior has a brownish-green hue. Their reaction with light points to their being augite.

*Magnetic Pyrites and Nickel-iron.*—Magnetic pyrites occur as grains inclosed in the other chondra and splinters of chondra, as well as free in the matrix. The nickel-iron is for the most part in the form of irregular particles with a hackly surface in the matrix. In some of the spherules both magnetic pyrites and nickel-iron have a distinct concentric arrangement.

The stone of Tieschitz belongs to that division of the chondritic meteorites which Tschermak some years since classified as remarkable for "many brown finely fibrous chondra." The specific gravity of the stone is 3·59. It contains about 85·0 per cent. of non-metallic minerals. No trace of any mineral resembling a felspar could be detected. The per-centage composition of the stone was as follows:—

| | Olivine | Bronzite and Enstatite | Augite | Magnetic Pyrites | Nickel-iron | Total — Calculated | Total — Analysis |
|---|---|---|---|---|---|---|---|
| $SiO_2$ ..... | 13·99 | 18·84 | 7·90 | — | — | 40·73 | 40·23 |
| $Al_2O_3$ . .. | — | — | 2·09 | — | — | 2·09 | 1·93 |
| FeO ..... | 13·86 | 5·47 | 0·73 | — | — | 20·06 | 19·80 |
| MgO ..... | 10·94 | 9·53 | 0·61 | — | — | 21·08 | 20·55 |
| CaO ...... | — | — | 1·42 | — | — | 1·42 | 1·54 |
| $Na_2O$..... | — | — | 1·26 | — | — | 1·26 | 1·53 |
| Fe ...... | — | — | — | 2·46 | 7·97 | 10·43 | 10·26 |
| Ni ... | — | — | — | — | 1·31 | 1·31 | 1·31 |
| S ......... | — | — | — | 1·62 | — | 1·62 | 1·65 |
| | 38·79 | 33·84 | 14·01 | 4·08 | 9·28 | 100·00 | 98·80 |

| | | |
|---|---|---|
| or, | Olivine ... ... ... ... ... ... ... ... ... ... | 38·79 |
| | Bronzite and enstatite ... ... ... ... ... ... ... | 33·84 |
| | Augite ... .. ... ... ... ... ... ... ... ... | 14·01 |
| | Magnetic pyrites ... ... ... ... ... ... ... ... | 4·08 |
| | Nickel-iron ... ... ... ... ... ... ... ... ... | 9·28 |
| | | 100·00 |

### 1878.—Whitfield County, Georgia.[1]

A fragment in the shape of a wedge was found to exhibit Widmanstättian figures of average size, which in certain places by the massive development of schreibersite were broken through: the band-iron is of average breadth, the interstitial iron distinguished by its unusual dark colour. In many places the magnetite fills partings which penetrate from the natural surface to a depth of 2 to 3 centimètres into the iron.

### 1879, May 10, 5 p.m.—Estherville, Emmet Co., Iowa.[2]

This curious meteorite fell near Estherville in lat. 43° 30′ N., long. 94° 50′ W., within that region of the United States which has been remarkable for falls of meteorites, three having fallen at Rochester in Indiana, Cynthiana in Kentucky, and Warrington in Missouri, within the space of a month. The phenomena attending this fall were of the usual character, but on a grander scale. It occurred about five o'clock in the afternoon of May 10, 1879, with the sun shining brightly. In some places the meteorite was plainly visible in its passage through the air, and looked like a ball of fire with a long train of vapour or cloud of fire behind it; and one observer saw it one hundred miles from where it fell. Its course was from N.W. to S.E. The sounds produced in its course are described as being "terrible" and "indescribable," at first louder than the loudest artillery, followed by a rumbling noise, as of a train of cars crossing a bridge. Two persons were within two or three hundred yards of the spots where the two larger masses struck the earth. There were distinctly two explosions: the first took place at a considerable height in the atmosphere, and several fragments were projected to different points over an area of four square miles, the largest going farthest to he east. Another explosion occurred just before reaching the ground, nd this accounts for the small fragments found near the largest mass. This latter fell within 200 feet of a dwelling-house, at a spot where there was a hole, six feet deep, filled with water. The clay t the bottom of the hole was excavated to a depth of eight feet before the meteorite was reached. The second largest mass penetrated blue clay to a depth of five feet, at a spot about two miles istant from the first. The third of the larger masses was found on the 23rd February, 1880, at a place four miles distant from the first, in a dried-up slough. On digging a hole the stone was met with at a depth of five feet. The fragments thus far obtained weigh respectively 437, 170, 92½, 28, 10½, 4 and 2 pounds. The height of the meteor is calculated to have been 40 miles, and its velocity from 2 to 4 miles per second. The masses are rough and knotted, like mulberry calculi, with rounded protuberances projecting from the surface on every side. The black coating is not uniform, being most marked between the projections. These projections have sometimes a bright metallic surface, showing them to consist of nodules of iron; and they also contain lumps of an olive-green mineral, having a distinct and easy cleavage. The greater part of the stony material is of a grey colour with the green mineral irregularly disseminated through it. The masses vary very much in density in their different parts; the average cannot be less than 4·5. When a mass is broken one is immediately struck with the large *nodules* of metal among the grey and green stony substance; some of these will weigh 100 grammes or more. In this respect this meteorite is unique; it differs entirely from the siderolites of Krasnojarsk, Atacama, etc., or the known meteoric stones rich in iron, for in none of them has the iron this nodular character. The large nodules of iron appear to have shrunk away from the matrix; an elongated fissure of from 2 to 3 millimètres sometimes intervenes, separating the matrix and nodules to the extent of one-half the circumference of the latter. The only mineral which could be picked out separately has a slightly green colour; it occurs in masses, from one half-inch to one inch in size, has an easy cleavage in one direction, and was found to be olivine. The same mineral occurs in minute rounded condition in other parts of the material; and minute, almost colourless, crystalline particles in the cavities are supposed to be olivine. Troilite exists in small quantity. A quantity of the silicates was picked out, separated as far as possible from iron, and treated with hydrochloric acid. The ratio of soluble to insoluble silicates varies very much in different parts of the meteorite, varying from 16 to 60 per cent. for the soluble part. The insoluble consisted of:—

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[1] A. Brezina. *Sitzber. Akad. Wiss.* 1880, lxxxii. Oct. part.

[2] J. L. Smith. *Amer. Jour. Sc.* June, 1880, xix. 459.

| | | Oxygen. |
|---|---|---|
| Silicic acid | 54·12 | 29·12 |
| Iron protoxide | 21·05 | 4·67 |
| Chromium oxide | trace | — |
| Magnesia | 24·50 | 9·80 |
| Soda with traces of K and Li | ·09 | 0·023 |
| Alumina | ·03 | 0·013 |
| | 99·29 | |

This is evidently the bronzite commonly found in meteorites.

The green mineral is the soluble part of the meteorite; its cleavage in one direction is very perfect; its specific gravity is 3·35; it has a hardness of almost 7, and is readily and completely decomposed by hydrochloric acid. On analysis it was found to have the composition:—

| | | Oxygen. |
|---|---|---|
| Silicic acid | 41·50 | 22·13 |
| Iron protoxide | 14·21 | 3·12 |
| Magnesia | 44·64 | 17·86 |
| | 100·35 | |

The mineral, therefore, is olivine. Dr. L. Smith, who has examined this meteorite, describes a third silicate which is opalescent and of a light greenish-yellow colour, and cleaves readily. It was a difficult matter to obtain enough of the silicate for analysis, but an examination of 100 milligrammes gave the following numbers:

| | | |
|---|---|---|
| Silicic acid | 49·60 | 26·12 |
| Iron protoxide | 15·78 | 3·50 |
| Magnesia | 33·01 | 13·21 |
| | 98·39 | |

This is equivalent to one atom of bronzite and one atom of olivine, which, he says, is "a form of silicate that we might expect to find in meteorites." The nickel-iron, as has already been stated, is abundant, sometimes in large nodules of from 50 to 100 grammes. It displays the Widmanstättian figures beautifully, and possesses the following composition:

| | |
|---|---|
| Iron | 92·001 |
| Nickel | 7·100 |
| Cobalt | 0·690 |
| Copper | Minute quantity |
| Phosphorus | 0·112 |
| | 99·903 |

A careful examination for felspar and schreibersite was made, but with a negative result.

(*To be continued.*)

## V.—On the Classification of the European Rocks known as Permian and Trias.

By the Rev. A. Irving, B.Sc., B.A., F.G.S.;
Senior Science Master of Wellington College.

(*Concluded from p.* 278.)

Of the *fauna* of the *Dyas* Credner remarks that it is much poorer than that of Carboniferous times, and with the exception of a few reptiles and fishes, limited to the marine formation of the series. Of all the lower forms Brachiopoda are by far the most prevalent, and furnish the most characteristic and most widely distributed of Zechstein remains. Lamellibranchiata assume, however, an importance unknown to them in earlier periods, and in their general character tend more towards Mesozoic than Palæozoic forms; he even suggests that *Schizodus* may be considered the 'precursor (Vorläufer) of the *Trigoniæ*.' Gasteropods are limited to a few genera and 20 species, the individuals being rare, insignificant, and small. Cephalopods are fast decreasing, two forms only occur in the Zechstein, and a very few more in Russia and America. Trilobites have quite disappeared, and are replaced by a Cypridean form and a _Limulus_ (?). Fishes are mostly heterocercal small-scaled ganoids, the abundance of individuals being enormous. The prevalent forms of the cold-blooded Vertebrata have taken a new type since the Carboniferous period, but Thecodont Amphibians have vertebræ still biconcave (as in fishes) and teeth set like those of the Crocodile. The development of Reptiles has made an important advance by the appearance of a higher type.

The German _Trias_ is poor in Cephalopods: _Nautilus bidorsatus_ is the chief representative of the Nautilidæ, while the Ammonitidæ have gained a footing in the form _Ceratites_. Quite otherwise and manifold is the character of the Cephalopoda of the Alpine Trias, the peculiarity of which consists in the assemblage found there of Palæozoic and Mesozoic types. Fishes of the Trias are partly heterocercal, small-scaled ganoids, though the non-symmetry of the tail is less marked than in ganoid forms of the earlier periods; the ossification of the vertebral column has also greatly progressed. True osseous fishes do not as yet exist. In some localities ganoid scales are so common in the upper strata of the German Bunter that some layers of the sandstone are coloured almost black by them. Remains of the oldest known mammal belong to the final stage of the Trias. In this period certain Crinoids (with the widely-distributed and highly characteristic _Encrinus liliiformis_, Lam.), Bivalves, Cephalopods, Reptiles, and Fishes play a prominent part.

_Comparative Table of the Organic Remains of the Dyas and Trias of Germany_ (after Credner).

| DYAS. | FLORA. | TRIAS. |
|---|---|---|
| _Caulerpites_* (fucoid) | | |
| _Calamites gigas_*<br>_Annularia_<br>_Asterophyllites_ | EQUISETACEÆ | _Equisetum arenaceum_* (B K).<br>_E. columnare_ (K).<br>_E. Lehmannianum_ (K).<br>_Schizoneura paradoxa_ (B). |
| _Neuropteris_<br>_Sphenopteris_<br>_Alethopteris_<br>_Odontopteris_<br>_Cyatheites_ tree-<br>_Psaronarius_* ferns<br>_Tubicaulis_* | FILICES | _Anomopteris_, with _A. Mougeoti_ (B K).<br>_Clathopteris_, with _C. Münsteriana_ (K).<br>_Gutbiera_ (B).<br>_Sagenopteris_ (B).<br>_Caulopteris Voltzi_ (B).<br>_Tæniopteris_, with _T. vittata_ (K).<br>_Pecopteris_, with _P. Stuttgartiensis_ (K). |
| _Nöggerathia_ | CYCADÆ | _Pterophyllum Jägeri_ (K).<br>_Pt. longifolium_ (K).<br>_Pt. Braunianum_ (K).<br>_Zamites_ (K).<br>_Otozamites_ (K). new types.<br>_Pterozamites_ (K) |
| _Walchia_<br>_Ullmannia_ | CONIFERÆ | _Albertia elliptica_ (B).<br>_Voltzia heterophylla_ (B K).<br>_Pallisya_ (K)<br>_Thuites_ (K) new genera.<br>_Palæoxyris_ (K) |

_Lepidodendron_ is rare, _Sigillaria_ and _Stigmaria_ almost extinct in the Dyas.

| DYAS. | FAUNA. | TRIAS. |
|---|---|---|
| (Very rare) | PROTOZOA | |
| *Calamopora*<br>*Alveolites* | CŒLENTERATA. | *Rhizocorallium Janense* (B). |
| (Very rare) | ANNULOIDA | *Encrinus liliiformis** (M).<br>*E. gracilis* (M).<br>*Aspidura scutellata* (M). |
| *Fenestella retiformis** | POLYZOA | |
| | CRUSTACEA | *Pemphix Sueuri* (M).<br>*Estheria minuta* (K). |
| *Spirifera undulata**<br>*Productus horridus**<br>*Strophalosia Morrisiana**<br>*Camarophoria Schlotheimi**<br>*Terebratula elongata**<br>*Lingula Credneri** | BRACHIOPODA. | *Terebratula vulgaris** (M K).<br>*T. angustata* (M).<br>*T. cycloides* (M).<br>*Retzia trigonella*<br>*Spiriferina fragilis*<br>*Spirifera Mentzeli* (Common to M and Alpine Trias.)<br>*Spiriferina hirsuta* (M).<br>*Rhynchonella Mentzeli* (M).<br>*R. decurtata* (M).<br>*Lingula tenuissima* (K). |
| *Schizodus obscurus*<br>*Avicula speluncaria*<br>*Arca striata*<br>*Mytilus Hausmanni*<br>*Gervillia ceratophaga*<br>*Pecten pusillus* | LAMELLI-BRANCHIATA | *Ostrea placunoides* (M).<br>*Pecten lævigatus** (M).<br>*P. discites** (M).<br>*Lima striata** and *L. lineata* (M).<br>*Gervillia socialis** (M K).<br>*Myophoria vulgaris** (M).<br>*M. costata** (B).<br>*M. lineata*, *M. pesanseris* (M).<br>*M. orbicularis*, *M. elegans* (M).<br>*Trigonodus Sandbergeri* (M).<br>*Myacites elongatus* (M).<br>*Unio* and *Anodonta* (K). |
| *Turbo*<br>*Pleurotomaria*<br>*Chiton*<br>*Natica*<br>*Dentalium* | GASTEROPODA. | *Dentalium læve* (M).<br>*D. torquatum* (M).<br>*Natica gregaria* (M).<br>*Turbonilla scalata* (M). |
| *Nautilus*<br>*Orthoceras*<br>*Cyrtoceras* | CEPHALOPODA. | *Nautilus bidorsatus* (M).<br>*Ceratites nodosus** (M).<br>*C. semipartitus*, *C. Buchi* (M).<br>*Rhyncholites hirundo* (M).<br>*Conchorhynchus avirostris* (M). |
| *Palæoniscus Freieslebeni*<br>*P. Vratislaviensis*<br>*Platysomus gibbosus*<br>*Amblypterus macropterus*<br>*Xenacanthus Decheni*<br>*Acanthodes gracilis* | PISCES | *Saurichthys* (M K).<br>*Gyrolepis* (M K).<br>*Semionotus Bergeri* (K).<br>*Ceratodus* (K).<br>*Acrodus* (M K).<br>*Hybodus plicatilis* (M K). |
| *Archegosaurus Decheni*<br>*Proterosaurus Speneri* | AMPHIBIA & REPTILIA | *Cheirotherium* (B).<br>*Trematosaurus* (B).<br>*Mastodonsaurus Jägeri* (K).<br>*Placodus gigas* (M).<br>*Nothosaurus mirabilis* (M K). |
| | MAMMALIA | *Microlestes* (K). |

* Highly characteristic of the DYAS and TRIAS respectively.

A review of the above table shows, (1) That of the *flora* of the two periods there is not a single *genus* of any importance which is known to range through both systems (2) That of the *fauna* only three genera of Brachiopods, two genera of Lamellibranchiates, two genera of Gasteropods, and one genus of Cephalopods common to oth systems are known. There is no instance of even a genus ɔmmon to both systems among the important classes Cœlenterata, .nnuloida, Crustacea, Pisces, Amphibia, Reptilia, Mammalia; and of f the whole fauna it has yet to be shown that there is a single pecies of any importance which ranges upwards from the Dyas into ıe Trias, or conversely.

### *General Conclusions.*

1. The general grounds on which geologists have been led to raw a rough line of demarcation between the Palæozoic and [esozoic Series have been so well stated by Sir C. Lyell in *Student's 'lements*, that it is needless to occupy space by repeating them here. f, however, the terms 'Palæozoic' and 'Mesozoic' are justified at all or the use of the more comprehensive term 'Cainozoic'), some .mit must be recognized in the application of them; and on such a rinciple of classification as is implied in the connotation of these ɜrms it is clear that *the succession of life-forms must be admitted to e of primary importance as evidence.* On the other hand, evidence btained from the petrographical character or stratigraphical sequence f the strata can be scarcely regarded as of more than secondary 'alue. The general impression left upon the mind is that, taken as whole, the series suggests on *physical* grounds the idea of a *vast eriod of transition* from the more strictly Palæozoic to the more trictly Mesozoic condition of things, yet with a sufficiently definite ɪreak in the succession of life-forms to warrant the division-line ɪeing drawn where it has been, provided only the importance of it ɪe not exaggerated. The stratigraphical evidence in favour of ;rouping them together is strong, so far as Germany and some areas n Britain are concerned, but it is not supported by the lithological :haracter of the Alpine Trias; since in the Alpine regions the ?ermians are only very doubtfully represented by rocks now highly netamorphosed, while the Triassic strata are almost entirely a ıuccession of marine deposits. The numerous organic remains 'ound in the latter strata, with their extraordinary admixture of ?alæozoic and Mesozoic types, warn us however against attaching oo much importance to the facts presented to us in the English and ɜerman areas which have so much in common; at the same time ,he palæontological facts connected with the Alpine Trias support :he view that the whole series is, on a broad and comprehensive view, one of transition. If, on the other hand, we must have a lefinite boundary-line, it is very difficult (and the difficulty increases with the fuller investigation of the matter) to see how such a line ɔould be drawn otherwise than as it has been drawn, at the horizon recognized in Germany as the boundary between the *Dyas* and the *Trias.*

2. While a distinction is thus recognized, it would seem that it has been by some geologists made too much of, and its importance perhaps in some cases exaggerated; and this has led to attempts to make too much of the Permian system, to construct a forced and artificial grouping for it in this country, by including within it

## TABULAR VIEW OF THE *DYAS* AND *TRIAS* OF EUROPE (=*POST-CARBONIFEROUS* AND *NEW RED SYSTEMS*.)

| | | England and Wales. | Ireland.[1] | Germany. | The Alps (after Credner). | |
|---|---|---|---|---|---|---|
| | | | | | (South.) | (North.) |
| Keuper. | | *c*. Rhætic or Penarth Beds (= *Avicula contorta* Zone) (passage series). | Rhætic Beds (Portlock.) | Rhät (= *Av. contorta* zone) ("Zwischenbildung"). | Overlying Zone of *Ammonites planorbis*.<br>Kössener Schichten and Dachsten Series.<br>'Hauptdolomit' of Tyrol, and 'Plattenkalk.' | |
| | | *b*. Upper Keuper Marls, etc., with gypsum, etc. | New Red Marl | Keuper Mergel (gypsiferous): very constant in its range. | Raibler Schichten, etc.<br>Schlern dolomite, etc. | *Cardita crenata* Beds, etc.<br>Wetterstein and Hallstatt Limestones, etc. |
| | | *a*. Lower Keuper Sandstone with brecciated base (generally calcareous) | Lower Keuper Sandstone. | Kohlenkeuper. | St. Cassian Beds, etc. | Marls with St. Cassian fossils, etc. |
| Muschelkalk. | | [Middle Marls of Mr. Ussher ? ?] | —— | Muschelkalk = Hauptmuschelkalk<br>Anhydrite Group<br>Wellenkalk | Wengener Schichten, etc. Partnach Beds, etc.<br>'Virgloria-kalk' and 'Mendola Dolomites.' | |
| Bunter. | | *c*. Upper Mottled Sandstone. | U. M. Sandstone. | Upper Buntersandstein (often gypsiferous.) | | |
| | | *b*. Conglomerate Series (often with clay-galls). | Pebble Beds ? | Coarse-grained Sandstone (including the upper grits of the Vosges). | β. Werfener Schichten (partly); including Guttensteiner Schichten of Hauer; Seisser Schichten of Wissman, Seisser and Campiler Schichten of Richthofen. | |
| | | *a*. Lower Bunter, Mottled Sandstones with dark red Sandstones (and subordinated breccias) at the base, including St. Bee's Sandstone. | —— | Lower Bunter; red and variegated Sandstone with interpolations of marls, gypsum, and dolomite (including the lower crystalline *Vogesensandstein*). | α Buntsandstein (proper) = Werfener Schichten (partly) of Hauer; Grödner Schichten of Richthofen.<br>[Marine forms only in the upper members of the Alpine Bunter.] | |
| Dyas, or Post-Carboniferous. | | *b*. Marls (often gypsiferous) with associated Magnesian Limestone: 'Marl-slate' and breccia as a lower member. | Mag. Limestone (Cultra and Tullyconnell) | Zechstein and Kupferschiefer, with a marine fauna. | —— | |
| | | *a*. Red Sandstones, breccias and conglomerates, including the Penrith Sandstone and 'Brockram' of the Carlisle Basin. | Conglomerate and breccia (Armagh) | Rothliegende, rich in land-plant remains. | —— | |

certain strata which are better regarded as members of the systems above or below it.

3. Since there is (when certain unnatural appendages are lopped off) a parallelism between the English Permian and the German Dyas, while such a parallelism between the Russian series and either the German or the English cannot be established, it seems that the adoption of the name 'Permian' for the group of strata known by that name in English geology has been unfortunate: a better term by which to designate it would have been 'Post-Carboniferous' (D. 'Postcarbonisch'), a term applied to the group by good writers both in England and in Germany. Personal esteem for the illustrious author of the former term will no doubt for a long time continue to give a sentimental preference for its use in many quarters. We should recollect, however, that this difficulty does not exist among the younger generation of geologists, for the use of whom mainly our text-books are written. In a science like geology, nomenclature, and in particular classificatory nomenclature, should, in the connotation of the terms used, be safeguarded against implication even of what may afterwards have to be unlearnt.

4. *Mutatis mutandis* the remark last made applies to the term 'Trias.' A Triassic order (in the sense in which the term is understood in Germany) does not exist in this country. Mr. Ussher,[1] indeed, tells us of an unbroken succession of strata in the south-west; but even if the sequence of which he tells us there be never disproved, it is clear that all that this gentleman has done is to establish the continuity of a series of sandstones and marls of Triassic age in that part of England; he has not any lithological grounds of a very definite character, and no warrant from fossil-remains, for calling his series a 'Trias,' much less for calling upon us to recognize this as the normal facies of the English series. This much is certain, that the series described in Mr. Ussher's paper do not answer to a correct definition of the German Trias as a system which "divides itself sharply into two sandstone- and marl-formations, the two being separated by a limestone-formation with a marine fauna, which is distinguished alike by poverty of forms and richness in individuals" (Credner). On the other hand, we have, not a complete Triassic system, but two definite formations (the Bunter and Keuper) of that system in the midland and northern counties, which are undoubtedly rocks of '*Triassic age.*' The adjectival term 'Triassic' is therefore exceedingly useful in English geological nomenclature, though it would seem advisable to discontinue altogether the use of the substantive word 'Trias,' as applied to our English strata. At the same time, the term 'New Red Sandstone' is hardly suitable, on account of its misleading *connotation* (and we cannot entirely disconnect the connotation from the denotation of such terms); 'New Red Series' or 'New Red System' would appear therefore preferable.

5. As to the uppermost limit of the New Red System, I should agree with Mr. Wilson,[2] in putting the greenish marls in the Keuper

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[1] *Vide* Q.J.G.S., vol. xxxiv.

[2] *Vide* Report of British Association, Section C, 1881.

Series (though I dissent from his views as to the origin of their colour). The *Avicula contorta Zone* (= 'Rhät') Credner describes as "a series of strata with prevailing clear finely-grained sandstones, which are covered with grey sandy shales, and enclose the remains of numerous vascular cryptogams and about 20 gymnosperms. They are found especially in the Rhætics near Bayreuth and near Culmbach, where they even form feeble seams of coal. . . . This Rhætic flora is certainly nearly related to that of the Upper Keuper; still the most important and characteristic species occur first in the Rhætic itself and pass up partly into the Jurassic System. The Rhætic is therefore linked to the Lias, or is a passage-formation ('Zwischenbildung') between this formation and the Keuper."

# REVIEWS.

## I.—GEOLOGICAL SKETCHES AT HOME AND ABROAD. By ARCHIBALD GEIKIE, LL.D., F.R.S., Director-General of the Geological Surveys of the United Kingdom. Royal 8vo. pp. 382, with 29 Illustrations. (London: Macmillan & Co., 1882.)

THE Essays here collected and revised have, says Professor A. Geikie, appeared at intervals in various journals, most of the papers being records of geological rambles, the author has introduced into them a few illustrative sketches from his note-books. Those who are already acquainted with Professor Geikie's many pleasant books on Geology and the Physical features of the Earth's surface, may anticipate not unnaturally to find the present volume sustain the high character of the author's other writings, and in this they will not be disappointed. We have here brought together, in a most agreeable form, graphic sketches with pen and pencil of many a beautiful spot in the Highlands and Orkneys; in Norway and Sweden; among the volcanos of Central France; in Wyoming; among the Geysers of the Yellowstone; a chapter on Geographical Evolution; and lastly an Essay on the Geological Influences which have affected the course of British History. From this last chapter we venture to quote briefly. "It is obvious that no event in the geological history of Britain can have had a more powerful influence on its human history than the separation of this country as a group of islands cut off by a considerable channel from direct communication with the mainland of Europe. Let us consider for a moment how the disconnection was probably brought about.

"There can be no doubt that at the time when Britain became an island, the general contour of the country was, on the whole, what it is still. The same groups of mountains rose above the same plains and valleys, which were traversed by the same winding rivers. We know that in the glacial and later periods considerable oscillations of level took place; for, on the one hand, beds of sea-shells are found at heights of 1200 or 1300 feet above the present sea-level; and on the other hand, ancient forest-covered soils are now seen below tide-mark. It was doubtless mainly subsidence that produced the isolation of Britain. The whole area slowly sank, until the lower tracts were submerged, the last low ridge connecting the land with France was overflowed, and Britain became a group of islands" (p. 359). Before this separation and—"previous to the final retreat of the Ice, the alternating warmer intervals brought into Britain many wild animals from milder regions to the south. Horses, stags, Irish 'elks,' roe deer, wild oxen, and bisons roamed over the plains; wild boars, three kinds of rhinoceros, two kinds of elephant, brown bears and grizzly bears, haunted the forests. The rivers were tenanted by the hippopotamus, beaver, otter, and water-rat; while among the Carnivora were wolves, foxes, wild cats, hyænas, and lions. Many of these animals must have moved in herds across the plains, over which the North Sea now rolls. Their bones have been dredged up in hundreds by the fishermen from the surface of the Dogger Bank" (p. 357).

Professor Geikie thinks that previous to this the flora of colder latitudes, together with the accompanying reindeer, musk-sheep, lemming, Arctic fox, glutton, and other northern animals had retreated from our low grounds (p. 356); but this could hardly have been the case; for in the Thames Valley deposits the remains of these high Arctic forms lie commingled in the same set of deposits with those presumably from lower latitudes; as if this region had, at that time, served as the meeting-place of faunas now geographically remote, but which then, had a far wider area of distribution.

To return, however, to the discussion of the isolation of Britain. "Unquestionably the isolation was helped by the ceaseless wear and tear of the superficial agencies which are still busy at the same task. The slow but sure washing of descending rain, the erosion of water-courses, and the gnawing of sea-waves, all told in the long degradation. And thus, foundering from want of support below, and eaten away by attacks above, the low lands gradually diminished, and disappeared beneath the sea.

"Now, in this process of separation, Ireland unfortunately became detached from Britain. We have had ample occasion in recent years to observe how much this geological change has affected our domestic history. That the isolation of Ireland took place before Britain had been separated from the continent may be inferred from a comparison of the distribution of living plants and animals. Of course, the interval which had then elapsed since the submergences and ice-sheets of the Glacial period must have been of prodigious duration, if measured by ordinary human standards. Yet it was too short to enable the plants and animals of Central Europe completely to possess themselves of the British area. Generation after generation they were moving westward, but long before they could reach the north-western seaboard, Ireland had become an island, so that their further march in that direction was arrested, and before the subsequent advancing band had come as far as Britain, it too had been separated by a sea channel which finally barred their progress. Comparing the total land mammals of the West of Europe, we find that while Germany has ninety species, Britain has forty, and

Ireland only twenty-two. The reptiles and amphibia of Germany number twenty-two, those of England thirteen, and those of Ireland four. Again, even among the winged tribes, where the capacity for dispersal is so much greater, Britain possesses twelve species of bats, while Ireland has no more than seven, and 130 land birds to 110 in Ireland. The same discrepancy is traceable in the flora, for while the total number of species of flowering plants and ferns found in Britain amounts to 1425, those of Ireland number 970—about two-thirds of the British flora. Such facts as these are not explicable by any difference of climate rendering Ireland less fit for the reception of more varied vegetation and animal life; for the climate of Ireland is really more equable and genial than that of the regions lying to the east of it. They receive a natural and consistent interpretation on the assumption of the gradual separation of the British Islands during a continuous north-westward migration of the present flora and fauna from Central Europe.

"The last neck of land which united Britain to the mainland was probably that through which the Strait of Dover now runs. Apart from the general subsidence of the whole North Sea area, which is attested by submerged forests on both sides, it is not difficult to perceive how greatly the widening of the channel has been aided by waves and tidal currents. The cliffs of Kent on the one side, and of the Boulonnais on the other, ceaselessly battered by the sea, and sapped by the trickle of percolating springs, are crumbling before our very eyes. The scour of the strong tides which pour alternately up and down the strait, must have helped also to deepen the Channel. And yet, in spite of the subsidence and this constant erosion, the depression remains so shallow that its deepest parts are less than 180 feet below the surface. As has often been remarked, if St. Paul's Cathedral could be shifted from the heart of London to the middle of the strait, more than half of it would rise above the water" (p. 362).

In this pleasant strain, Prof. Geikie puts before his readers the great geological facts which science has accumulated in the past fifty years.

His later American experiences will be read with equal interest. We heartily commend the volume to our readers.

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## II.—Memoirs of the Geological Survey. England and Wales. The Geology of the Country Around Norwich. (Explanation of Quarter-sheets 66 N.E. and 66 S.E. of the One-inch Geological Survey Map of England and Wales.) By Horace B. Woodward, F.G.S. (Notes by J. H. Blake, F.G.S., and C. Reid, F.G.S.) Lists of Fossils revised by R. Etheridge, F.R.S. London: Edward Stanford, jun., 55, Charing Cross, S.W., 1881. Royal 8vo. pp. 216, with 8 Plates, a page Woodcut, and Folding Table. (Price 7*s*.)

"ONE of the earliest geological descriptions of Norfolk,"—writes Sir Andrew C. Ramsay, in his Notice of this Memoir,—"was published by Samuel Woodward in 1833. To the grandson of this old geologist has been confided the task of preparing the present Geological Survey Memoir, which I think will be found not unworthy of its author and his name."

A higher commendation of the author by the head of his department could hardly have been given, and it is very satisfactory to feel that it is a well-earned testimony to Mr. Horace B. Woodward's ability as a field-geologist and an author, not only of several Survey Memoirs and Maps, but also of a most valuable text-book on the Geology of England and Wales, giving a concise account of the lithological characters, leading fossils and economic products of the rocks, with notes on the physical features of the country; a text-book which should be in the hands of every geological student.

Previous to the publication of S. Woodward's "Outline of the Geology of Norfolk" (1833), but little had been attempted in exploring the geology of this north-eastern portion of East Anglia; indeed but few geological works of any kind then existed. Mantell's Geology of the South-East of England; Phillips's Geology of Yorkshire; Dixon's Geology of Sussex, and other similar works, testify to the utility of this district or county form of geological publication.

The Memoir before us is restricted to the exact area of the two Quarter-sheets (66 N.E. and 66 S.E.) of the Geological Survey Map; or about 412 square miles; whereas the whole county of Norfolk embraces an area of 2119 square miles, so that these sheets cover rather less than one-fifth of the entire county. The area described extends from Bungay and Beccles on the south to Buxton and Tunstead on the North of Norwich; and from Reedham and Potter Heigham on the East to Bawburgh, Hethersett, and Wrenningham on the West of Norwich.

It is greatly to be desired that, hereafter, the description of the other portions of the county should be brought together in a single volume or into two volumes, one for East, and the other for West Norfolk; and we feel assured that such a division of the area would be far more acceptable to the local geologists and landed proprietors who desire to consult the pages of these memoirs as to their native county.

We hope that one day it may fall to the lot of Mr. Horace B. Woodward to bring out the joint memoirs of himself and colleagues on the geology of the entire county, as his grandfather did in 1833.

With the exception of the coast sections and a pit at Burgh near Aylsham, all the fossiliferous Norwich Crag sections in Norfolk are described.

Those who object to the multiplicity of local names will be glad to find that under the comprehensive name of "Norwich Crag Series" are grouped the Mammaliferous Stone-bed, the Fluvio-marine Crag, the Chillesford Shell-bed, the Chillesford Clay, and the Bure Valley beds. With regard to the Crag Mammals, it is stated that "the evidence shows that the bones may belong to the period as much as the shells, which occur abundantly in the Stone-bed and in crevices of the Chalk."

Among the theoretical questions briefly discussed are the origin of flints, including the gigantic paramoudras, and the origin of the large Chalk boulders of Norfolk.

Most valuable lists of the Fossils of the Upper or Norwich Crag, and of the Upper Chalk (revised by Mr. Robert Etheridge, F.R.S.) accompany this memoir, and the Appendix gives a most complete Bibliography of every paper relating to the geology of the county (to which Mr. W. Whitaker, F.G.S., contributes).

The formations noticed in the area described, or proved by deep borings, are as follows :—

| | | |
|---|---|---|
| Recent and Post-Glacial | Alluvial Deposits ... | Alluvium.<br>Brickearth.<br>River Gravel. |
| Pleistocene—Glacial Drift... ... ... | | Gravel.<br>Boulder Clay.<br>Brickearth (laminated).<br>Sand and Gravel.<br>Brickearth. |
| Pliocene ... ... ... ... ... ... ... | | Upper Crag—Norwich Crag series (k '2). |
| Cretaceous ... ... ... ... ... ... | | Chalk (h 5).<br>Upper Greensand (h 4).<br>Gault (h 3). |

The symbols (k '2) and (h 5) are engraved on the Map.

No rocks older than the Cretaceous period have been proved in the area; the possibility, however, of Carboniferous rocks (including Coal-measures) being reached at a depth of about 1200 feet was shown by the author when President of the Norwich Geological Society in his Anniversary Address (Nov. 4th, 1879); see GEOL. MAG. 1880, Decade II. Vol. VII. pp. 72-78, and was illustrated by a woodcut (p. 75), now reproduced in this Memoir.

The Chalk of Norfolk is interesting as probably exhibiting higher beds than occur elsewhere in England. The occurrence of remains of *Leiodon* or *Mosasaurus*, a lacertian reptile, found also in the still higher Cretaceous beds at Maestricht, in Holland, favours this idea.

We are glad to see Sir Andrew Ramsay's remark that "in the grouping of the Glacial Beds the author has simply adopted a classification applicable to the district, being of opinion that no general classification can be established until the Glacial Beds are minutely mapped over much larger areas. This work is now in progress by the Geological Survey. As it proceeds, we shall probably learn that these beds are less complex than they appear to be, and that many of the divisions have only a local value." Mr. H. W. Bristow, F.R.S., the Senior Director, mentions the interesting fact that Mr. Horace B. Woodward has surveyed and mapped the geology on a copy of (the late City of Norwich Surveyor) Mr. A. W. Morant's large map of the City of Norwich, on a scale of five chains to an inch. This large and valuable original map is to be deposited, for reference, in the Geological Survey Office, 28, Jermyn Street, S.W.

Considering the excellence of the memoir, it is much to be regretted that the eight lithographic plates of sections at the end have not been executed in better style. They contrast most unfavourably with the lithographs published fifty years ago in Samuel Woodward's Outline of the Geology of Norfolk, when lithographic art was then in its infancy. Surely Her Majesty's Stationery Office should have their attention drawn by the Director-General to such execrable lithographic printing, discreditable to any London firm. The lithographer discreetly veils his name.

III.—SYMMETRY ON THE TERRESTRIAL SPHERE. La Symétrie sur le Globe Terrestre. Par A. DE LAPPARENT, Professor à L'Institut Catholique de Paris. Extrait de la Revue des Questions Scientifiques, Janvier, 1882.

THIS article places before French readers an adaptation by Mr. Lowthian Green of M. Elie de Beaumont's Polyhedron Theory of the Earth's Surface. He is of opinion that the cooling earth shrank into a form based on that of a Tetrahedron. To three of the projecting angles are due the elevation of Europe, Asia, and North America; the fourth is at the Antarctic Pole. The form is to be more strictly that arising by development of pyramids on the original four faces: thus are explained S. America, Africa, Australia, and Greenland. The shrinking in the southern hemisphere produced a tendency to increased rotation, to which is attributed a more easterly position of these three southern land masses. While these were being so shifted, the depressions of the Mediterranean and the Gulf of Mexico took place, under the action of tides in the molten interior determined in some peculiar way by the position of the Ecliptic. The obliquity of the Ecliptic is itself accounted for by the attraction of the sun on the projecting points of the tetrahedron.

M. De Lapparent's views on the rotation of tops do not agree with phenomena observed in the streets. What does he mean by saying that conjunctions of the sun and moon are most frequent at the solstices?

The reader must not take for granted any statements involving either Dynamics or Astronomy. It is possible that "the authors of recent manuals" have neglected the original treatise for other reasons than that assigned by M. De Lapparent. E. H.

## REPORTS AND PROCEEDINGS.

### GEOLOGICAL SOCIETY OF LONDON.

I.—May 10, 1882.—J. W. Hulke, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Relations of *Hybocrinus*, *Baerocrinus*, and *Hybocystites*." By P. Herbert Carpenter, Esq., M.A. Communicated by Prof. P. Martin Duncan, M.B., F.R.S., V.P.G.S.

The author discussed the relations of *Apiocrinus dipentas*, Leucht., and of *Baerocrinus Ungerni*, Volborth, both from the Lower Silurian of Russia, to *Hybocrinus*, Billings, of the American Trenton limestone.

*Ap. dipentas* was regarded as a true *Hybocrinus*, as it was by Volborth and Schmidt; but the author followed Volborth and Grewingk in considering *Baerocrinus* as a distinct generic type. The calyx consists of five basals supporting five radials, of which only three bear arms, while there is no indication of any anal system, unless it be the so-called Volborth's organ. *Baerocrinus* is probably to be regarded as a permanent larval form, which has only developed arms on three of its radials.

*Hybocystites problematicus*, from the Lower Silurian of Kentucky, which is supposed by Wetherby to be an intermediate form between the Crinoids and the Cystids, is believed by the author to be more closely allied to the Blastoids than to the Cystids. The three so-called arms are merely upward prolongations of the radials, which are segmented in the same way as the downward extending radials are in *Pentacrinus briareus*. They are not arms like those of *Hybocrinus* and other Crinoids. Of the five ambulacra that diverge from the peristome, the right and left anterior ones pass directly downwards from the summit on to the corresponding radials, and thence on to the basals. The other three ascend the inner faces of the short radial extensions, pass over their tops and down their outer faces, where they have been described as "more or less obscure furrows, of which nothing further is known." In some cases they reach the basals, and in others not, exhibiting a considerable amount of variation both in this and in other respects. There are therefore five recurrent and appressed ambulacra, and not two only, together with three arms, like those of Crinoids.

2. "On the Madreporaria of the Inferior Oolite of the Neighbourhood of Cheltenham and Gloucester." By R. F. Tomes, Esq., F.G.S.

The author called attention to the observations of Milaschewitsch on "Rejuvenescence" in corals, published in vol. xxi. of the Palæontographica, and explained its nature as opposed to "gemmation." He suggested that, in describing corals, the following classification of the costæ should be adopted:—

1. *Mural costæ*=those which appear on the wall, whether of simple or compound species.
2. *Septal costæ*=those which are a prolongation of the septa.
3. *Intercalicular costæ*=those which cover the cœnenchyma between the calices.

He adopted in general Dr. Wright's views as to the stratigraphical position of the coralligenous deposits in the Gloucestershire Inferior Oolite, and gave a tabular statement of the distribution of the species in the several coral-beds, pointing out that each of these has its own species, which do not pass much from one to the other. He recorded about sixty species, many of which were described as new, and proposed two new genera (*Phyllogyra* and *Phylloseris*), besides introducing five or six genera previously characterized on the Continent, but not recognized in England, namely, *Donacosmilia, Confusastræa, Chorisastræa, Oroseris*, and *Dimorpharæa*.

The author referred especially to some so-called *Thecosmiliæ*, such as *T. gregaria*, and insisted that they should be removed to the genus *Chorisastræa*, as they increase by gemmation at the base only of the corallum, and never by fissiparity, as in the type of

*Thecosmilia*, namely, *T. trichotoma*, from the Corallian of Nattheim. He remarked upon the characters of the genus *Heterogyra*, Reuss, and its allies, including his new genus *Phyllogyra*; and further indicated that *Thamnastræa* and allied genera have been removed by Milaschewitsch from the Fungidæ and placed among the Poritidæ, in consequence of their perforated septa, an alteration in which he agreed.

3. "On the Exploration of two Caves in the Neighbourhood of Tenby." By Ernest L. Jones, Esq. Communicated by Prof. W. Boyd Dawkins, F.R.S., F.G.S.

The caves noticed in this paper were that of Coygan, near Laugharn, partially described by Dr. Hicks in the GEOLOGICAL MAGAZINE in 1867, and a cave known as Hoyle's Mouth, reported on to the British Association in 1860 by the Rev. Gilbert N. Smith. Both caves were rock-fissures. The Coygan cave had been a Hyæna den, as was shown by the deposits of crushed bones and coprolites trodden down into a solid mass by the passing of the animals. Besides remains of Hyæna, it furnished those of Horse, Mammoth, Tichorhine Rhinoceros, Elk, Red Deer, Roe Deer, Reindeer, Cave Bear, Cave Lion. *Bos primigenius*, Wolf, and Fox. The presence of Hippopotamus was doubtful. Besides these animals, the presence of Palæolithic man in the cave was indicated by some cut bones and by two flint-flakes evidently chipped by man. In the second cave, Hoyle's Mouth, the Hyæna, the Cave Bear, etc., were wanting, the place of the latter being taken by the common Brown Bear. In one part remains of an old hearth were found; and the whole contents of the fissure pointed to a Neolithic date. At one time the cave appears to have been used as a place of sepulture.

4. "Note on the Comparative Specific Gravities of Molten and Solidified Vesuvian Lavas." By H. J. Johnston-Lavis, Esq., F.G.S.

From some experiments made on Vesuvian lava, Prof. Palmieri in 1875 expressed the opinion that its specific gravity, when molten, might be as high as 5·0, though when cooled it is only 2·7. The author described the results of experiments made in December, 1881, on some lava flowing across the Atrio del Cavallo. Favourable circumstances enabled him to gain a position above a perfectly molten stream, the surface of which was protected from radiation by the heated walls of a tunnel which the lava had already formed by cooling of the crust. On to this were dropped, from a height of 1½ yard, (*a*) light scoria; this floated on the surface until lost to view (the stream could be watched for 150 yards or so); (*b*) fairly solid lava, with some vesicular cavities: this slowly sank, until after some distance it disappeared; (*c*) the most compact lava that could be found, in which, however, were a few small cavities: this sank rapidly, the molten rock welling up round it. The author considered that these experiments demonstrate that the cooled lava is more dense than the molten, and that the apparently contradictory results obtained by Prof. Palmieri were due to the fact that the surface of the stream, by loss of heat, had become viscid, so that the solid material floated, though of greater density. The author concluded by citing other confirmatory evidence of his view.

II.—May 24, 1882.—1. "On the Geology of Costa Rica." By George Attwood, Esq., F.G.S., F.C.S., Assoc. Memb. Inst. C.E.; with an Appendix by W. H. Hudleston, Esq., M.A., F.G.S., F.C.S.

The author commenced his journey at the town of Punta Arenas, on the Gulf of Nicoya. This stands on a peninsula composed of a calcareous sandstone, covered by a dark sand consisting of quartz grains, magnetite, and decomposed felspar and augite. Inland is an igneous rock which occupies, before long, both banks of the Rio Barranca, and on the left bank extends to the sea; it is a greenstone containing porphyritic crystals of augite and triclinic felspar, and appears to contain too much silica for a true dolerite, being rather a representative of one of the more basic forms of the augite-andesites, resembling, in some respects, specimens from the English lake-districts described by the late Mr. Clifton Ward. On this rock, after a time, are found boulders of a black augite-andesite; this appears to be identical with the rock found *in situ* in the Aguacate mountains. Here are gold- and silver-mines, which were described. In the ravine of the Rio Grande lignites are found. Below this is a series of ancient lakes, which on the Pacific slopes have been tapped by the Rio Grande, on the Atlantic by the Rio Reventazon. Here also the country rock is the greenstone already described; and near Cartago there are boulders of trachyte. The volcano of Irazu is a trachyte, probably a quartz-trachyte, forming an important building-stone. Augite-andesites are found at La Palma, about twelve miles N.W. of the volcano. Irazu, a volcano at present passive, but with blow-holes of gas, is between 11,000 and 12,000 feet in height. Turrialba, of about the same elevation, is still feebly active.

The author is of opinion that the filling of the mineral lodes (ancient fissures) in the Aguacate mountains took place in Tertiary times, probably Pliocene, and that this infiltration was contemporaneous with the eruption of the augite-andesites in the same region. The quartz-trachytes and sandstones are certainly Post-Tertiary.

2. "On a remarkable Dinosaurian Coracoid from the Wealden of Brook, in the Isle of Wight, preserved in the Woodwardian Museum of the University of Cambridge, probably referable to *Ornithopsis*." By Prof. H. G. Seeley, F.R.S., F.L.S., F.G.S., etc.

The specimen described was obtained in 1866 by Mr. Henry Keeping, midway between the fossil forest at Brook Point and Brook Chine, about 10 feet above high-water mark. The author stated that it was the largest Dinosaurian coracoid known to him, that it differed in important characters from that of *Iguanodon*, and that, of described genera, it most probably belonged to *Ornithopsis*. The bone is from the right side, and nearly perfect; its length is about 16½ inches and its greatest breadth about 14 inches; the humeral articular surface is nearly 8 inches, and the suture for the scapula about 10½ inches long. The bone is moderately thick, slightly convex externally and concave within, thickened at the humeral articulation. The nearest approach to this coracoid is made by that of the skeleton referred to *Hylæosaurus*, from the Wealden of Tilgate; but in it the distal portion of the bone is more prolonged, the median portion is less thickened, and the foramen is placed behind the middle of the humeral border, far away from the scapular margin, near which it is situated in the present bone. From the coracoid of *Iguanodon* it differs by the absence of the notch between the humeral and scapular surfaces, which there represents the foramen in this bone. In some respects it resembles certain American types, such as *Morosaurus*, and especially *Camptonotus*.

3. "On the Newer Pliocene Period in England." By S. V. Wood, Esq., F.G.S. (Concluding Part.)

In this part the author continued, from the first part of the paper published in the Journal of the Society for 1880, his examination of the conditions which accompanied the emergence of England during the retreat of the ice of the Chalky Clay, and described the damming-up of the valleys which drain to the Wash by that ice after the water-partings between their systems and those of the Severn and Thames had emerged, whereby the fresh water in these valleys was raised, so as to overflow the minor water-partings within their systems and cover them with gravel, such as that at Casewick, within the Welland system (described by Prof. Morris in vol. ix. of the Journal), and those of Cambridgeshire, described by Mr. Jukes-Browne. He thus referred the freshwater bed at Casewick, covered by this gravel, and the palæolithic brick-earth of Brandon and Mildenhall (which is overlain as well as underlain by the Chalky Clay) to the time immediately antecedent to this—the slight advance of the ice which thus blocked up and raised the water-line within the systems of the Welland, Nen, Ouse, and Cam having overridden this brick-earth and covered it with the Chalky Clay.

He then described the gravel (*f* of his figures) of the Thames valley, and showed that it was the continuation of the gravel previously described by him as synchronous with the Chalky Clay, and which, as described by him in the first part of his paper, was *over*lain, and also *under*lain by that clay, it inosculating with those gravels, up the valleys of the Lea and (Middlesex) Colne.

He then described the *Cyrena-fluminalis* formation, which he showed as originating in a depression which raised the water-line in the Thames valley at Grays and Crayford to about 100 feet above the present sea-level, and proportionately higher on the west of London; and described the formation as consisting, at Grays, of four divisions, which in their upward order he called 1, 2, 3, and 4,—No. 1 being the gravel base, No. 2 mostly brick-earth with freshwater shells, No. 3 yellow sand containing freshwater shells in the lower part, but unfossiliferous and false-bedded in the upper, and No. 4, a clay or loam, also unfossiliferous.

These, he showed, are mutually transgressive, both at Grays and at Clacton, No. 3 at Clacton becoming estuarine by the intermixture of marine shells with the *Cyrena*, and No. 4, a loamy gravel which is unfossiliferous; while, from its greater transgression, No. 4 spreads so widely over the gravel *f*, that remnants of it occur at Slough, West Drayton, and other places. He then traced the formation northwards in Suffolk, where, from the *Cyrena* not being associated with other than freshwater shells (except at Gedgrave, where the marine shells associated with it are derivatives from the Crag), he inferred that the depression did not bring the sea into Suffolk or East Norfolk. In West Norfolk and around the Wash, however, it did so, the *Cyrena* being associated with the marine gravel at March. The evidences of this depression bringing in the sea around the Wash (which consist of the Nar brick-earth and the gravel of Hunstanton, March, and other places in the Fen country with marine shells) extend to about 30 feet elevation. This gravel at Overton, near Peterborough, passes down into a bed with freshwater shells only, thus resembling the Clacton bed, and at March containing the *Cyrena* in abundance. Northwards the formation is represented by the *Cyrena*-gravel of Kelsea Hill, in Holderness; and the evidences of depression rise in that direction to near 100 feet, as a brick-earth, at Kirmington in North Lincolnshire, at between 80 and 90, containing mammalian remains and *Scrobicularia piperata*, with valves united, is regarded by the author as part of the formation; and there he instanced the ripple-marked pan beneath this formation at Hessle as evidence of redepression or transgression, similar to that afforded by the Mollusca at Overton and Clacton. He then described this gravel as extending up the vales of York and Tees to about similar elevation, and as passing in them, as it does in Holderness, under the clay of the minor glaciation. Southwards he traced the formation as represented by the shingly sand and gravel of Avisford and Bourne Common in Sussex; the Selsea mud-bed with Lusitanian shells, near the present sea-level, representing the first part of the formation, which the depression carried transgressively to Avisford. In the Thames and lower Lea valleys he described, and showed, by many lines of section, how considerable a denudation accompanied the rise from this depression, so that not only most of the formation but also much of the gravel *f*, of glacial age, on which the uppermost bed of this formation rested, was washed away, the latter having for a great distance been left on an escarpment facing the valley sides. This denudation, he showed, was in the same places repeated after the formation of the gravel of the minor glaciation.

Under the division of minor glaciation or reindeer age, he described the various formations, morainic, atmospheric, fluviatile, and marine, due to a return of glaciation after England had, except in the north-west, become all land. The morainic part in the north-west (which was the Upper Clay of Lancashire and adjoining counties) he regarded as extruded beneath the sea up to that level at which it contains shells, these having been dropped from floe-ice detached from the shores, which drifted over it while thus undergoing extrusion; but in the north-east it was terrestrial, owing to this part having emerged from the depression of the *Cyrena* formation before the moraine reached Holderness, and therefore it contained no shells. The ice giving rise to this moraine was of far less volume than that of the Chalky Clay, and instead of seeking the sea as that did, when the sea lay over the centre and south of England, it passed to it in its present position, one stream of it going straight out through the Tees valley, and another down the vale of York and out by the Humber, so as to overspread southern Holderness and the sea-board of Lincolnshire. The fluviatile formation of this minor glaciation is the gravel which overlies the *Cyrena*-formation at Crayford and Ilford (Uphallfield) up to the elevation of about 30 feet, and at similar elevation lies up to the foot of that formation at Grays; and it is that which forms the 40–45-foot terrace at Acton, where it has yielded reindeer-remains. Owing to the rise from the depression under which the *Cyrena*-formation accumulated, which had taken place when this gravel was formed, its level does not differ greatly from that of the *fossiliferous* part of the *Cyrena*-formation at Grays and Crayford, so that in more inland districts, as at Oxford, the two, though quite different in age, may be undistinguishable. This gravel the author regarded as corresponding in position with the beaches of the buried cliffs of Sangatte, Brighton, Isle of Wight, Portland, and Sili Bay, these beaches and the gravel having originated during a pause in the rise from the depression of the *Cyrena*-formation. The floe-ice of this glaciation driven on to these beaches left blocks on them, which becoming mixed with loam from rills pouring in summer over the cliffs, is covered by the atmospheric formation which accumulated as, by renewal of emergence, the sea receded from these beaches. At the same time floes grounding on the Pagham and Selsea flats, which, in correspondence with the shingle of the Isle-of-Wight beach, were then submerged about 30 or 40 feet below their present level, left the great blocks found in the clay-gravel of Pagham and Selsea which was then forming, and which overlies the mud-bed with Lusitanian shells, and is itself overlain by the atmospheric formation. He also showed by a line of section that this gravel occupies a position several hundred feet below that which the gravel of the great submergence and major glaciation occupies in the adjoining parts of Hampshire.

The atmospheric formation of the minor glaciation, he regarded as the brick-earth with angular fragments of stone and splintered flints overlying the buried cliffs and their beaches. This is the "formation of great submergence" (with land shells and Mammalian remains) of Prestwich, and identical with the "warp" of Trimmer and "trail" of Fisher in other parts of England. The origin of this he referred to an annual thawing of the upper layer of the permanently frozen land-surface, such as takes place in arctic countries not occupied by land-ice, such as Siberia. Owing to the subsoil being permanently frozen, no water can penetrate it, so that the thawing surface-layer becomes sludge from the snow-melting and rainfall of summer, and slowly slides from higher to lower places, thus exposing on the higher a continually renewed superficial portion of the permanently frozen soil to this action, and accumulating it in the lower. In sliding, this material has collected not only the bones of animals such as the reindeer and mammoth which lived on this surface, but also those of the hippopotamus, which did not, but had lived during the *Cyrena*-formation stage, from superficial deposits of that stage (from which also they got by derivation into the gravel of this glaciation), in illustration of which he refers to Siberian rivers now receiving the remains of the extinct mammoth and living reindeer alike.

Penetrating fissures in the rocks, this material has formed the amorphous Cave-earth of the districts beyond where the moraine has reached; and the author pointed out that, stalagmite being due to percolation, none could form while the subsoil was thus permanently frozen, which is the reason why the Cave-earth is devoid of it, though always covered by it and sometimes underlain by it, such underlay probably showing that the caves where this occurs were not submerged at the commencement of this minor glaciation.

After giving various reasons which appeared to him to show that the passing away of the minor glaciation took place while Lancashire was still submerged up to an elevation of from 20 to 30 feet, but when the east and south of England was at a somewhat higher level than at present, he described a bed of flattened stones which cover all anterior beds alike in the limestone districts of the south of Lincolnshire, and some gravel with flattened fragments of hard chalk in North Lincolnshire and Holderness which appear to him to indicate a flooding of the country after the termination of this glaciation. The author then offered some remarks on the co-existence of arboreal vegetation with the land-ice of the first or great glaciation at the time when it uncovered the plateaux of Norfolk and Suffolk, appealing for the probability of this to the condition of South America, where the inland ice passes in glaciers to the sea in the Straits of Magellan and adjoining channels through dense forests. He also pointed out that the evidences of the Newer Pliocene period, as traced by him, lend no support to the climate-theories of Dr. Croll, Mr. Wallace, or Mr. Murphy, but, on the contrary, conflict with them, as do the respective extensions of the areas of glaciation in Western Europe and Eastern America, while they are equally repugnant to any theory of climate based on changes in geographical conditions; and he concluded by insisting on the British origin of all the ice connected with either glaciation in England, and on the existence of an open north sea throughout.

## CORRESPONDENCE.

### J. P. LESLEY ON HIGH-LEVEL DRIFT.

SIR,—I notice the following on page 186, No. 214, GEOLOGICAL MAGAZINE:—"The author [D. Mackintosh, Esq., F.G.S., paper entitled, "Additional Discoveries of High-level Marine Drifts, etc."] begins with remarks on the importance of the marine drift-area, . . . especially as regards its great extent, and the absence, so far as yet known, of similar high-level drifts (between 1000 and 1350 feet above the sea) in Continental Europe, Asia, or North America."

The annual reports published by Professor Geo. H. Cook, State Geologist, give the information which Mr. Mackintosh finds wanting. The vignette to the pamphlet report of 1877 is a Map of the State, showing its northern part wholly covered with drift. The line of the terminal moraine is drawn, and lists of striæ with magnetic *directions.* These tables are continued in the report of 1878, and he striæ and drift deposits are described as covering the high lands f the State. The line of moraine mounds and hollows, with large oulders, crosses Schooley's Mountain at an elevation of between 1200 and 1300 feet. Back from this, to the N. and N.E., the nountain ranges are drift-covered as well as the valleys, but the mountain crests are nearly destitute of drift, although boulders are perched upon them. A large glacial map of New Jersey accompanies this report. The report of 1879 gives a still larger coloured geological map of the State; and this also shows the drift-covered area. The report of 1880 describes the terminal moraine in great detail, with a table of elevations (highest in Waterloo township, 1250′ A.T.); moraines of recession; modified drift; transported drift; preglacial drift; drift dams and ponds, etc. The report of 1881 gives the heights of Hamburgh mountain as 1488′; Scotts mountain 1277′; the Schooley mountain range as varying from 900′ to 1500′; the Kittatinny (Schawangunk) mountain as 1474′ at the Delaware water-gap, and 1800′ at the New York State line, the highest ground in the State.

The reports of progress of the Second Geological Survey of Pennsylvania describe much higher drift-covered areas. I am putting through the press Report G 6 (by Prof. I. C. White) on Pike and Monroe counties, which border on the north line of New Jersey. Through these counties ranges the high plateau of the Catskill mountains, (Devonian), from N.E. to S.W., cut by the long cañons of the Delaware and Lehigh rivers descending from the north. In New York State this plateau averages 3000′ above tide, with peaks (measured by Guyot) Overlook 3600′, Monk 3880′, Blackhead 3965′, and others up to 4052′, 4179′. But in Pennsylvania the average height of the plateau is under 2000′. The Delaware and Lackawanna railway crosses it with a summit grade of 1681′. Near this lies Elich's pond in a kettle of glacial drift at 1754′. The front edge of the escarpment (a horizontal conglomerate 100 feet thick) ranges at about 2000′ A.T. From this front edge the plateau slightly declines north-eastward, with outlying fragments, such as North and South Knobs (2010′ A.T.). But northwards it maintains its elevation; the railway summit grade being 1955′ next south of the Tobyhanna creek, and 1970′ next north of it. This Tobyhanna creek flows under the railway bridge at 1932′ A.T. through a very shallow valley of drift.

Pocono Knob projects eastward from an angle of the escarpment (where it turns north), and is about 2000′ A.T. The notch behind it which isolates its summit from the rest of the plateau is 1681′ A.T. Another Knob on the brow of the escarpment reaches 2225′ A.T. The terminal moraine creeps up the escarpment, encircles Pocono Knob at two-thirds its height (from base to top, say 1000′), and reaches the plateau level from behind. From this point it stretches off N.W. across the plateau at a height of 2000′ A.T. in the form of a mound-wall about 100′ high. Long Pond has been created by it, obstructing a preglacial valley with its trash.

The entire area of the plateau behind the terminal moraine, *i.e.* the whole of Monroe, Pike, Wayne, and Susquehanna counties lying to the north-east of it, is an unbroken sheet of Drift, with the usual aspect of Till, with loose boulders, striæ on exposed outcrops, drift dams, buried valleys, reversed drainage, and innumerable drift inclosed ponds and lakes, the elevations of which above tide are given by Mr. White in his report; the lower ones like Nichecronk and Silver Lakes, 1150′ and 1250′; the higher ones like Lakes Belle and Ernest 1750′, Lake Laura 1800′, Elich's Pond 1754′.

In Mr. White's Report, G 5 (1881) on Wayne and Susquehanna counties, lying next the New York State line, similar descriptions and tables of elevations of striæ, drift ponds, etc., are given; and the exact uppermost limit of ice action is there to be seen, on the sides of isolated peaks. The highest striæ on Mount Ararat being 2200′ above tide. The elevation of the whole region may be gathered from the fact that the lowest summit that the Jefferson Branch Railway could find for its grade is 2023′ A.T. Hundreds of morainic ponds and lakes dot the whole map.

I hope to put to press shortly the special report of Prof. H. C. Lewis, whom I directed to trace and study the terminal moraine throughout its whole line, a distance of about 450 miles, *i.e.* from where it crosses the Delaware and enters our State from New Jersey, near the Water Gap, to where it leaves the State to enter Ohio west of Pittsburgh. In this report Mr. Lewis maps the moraine as ascending and descending our mountain sides, crossing narrow and wide valleys, ascending the Alleghany mountain plateau and traversing the highest lands in Northern Pennsylvania.

The report of Mr. Ashburner on McKean county, and that of Mr. Carll on the Oil Regions, treat largely of our high-level drift and the astonishing changes it has effected in our topography. There is, therefore, no lack of data for Mr. Mackintosh to use; data, be it said moreover, of the most precise and complete kind.

1008, Clinton Street, Philadelphia. J. P. Lesley.

THE SO-CALLED HYPERSTHENITE OF CARROCK FELL.

Sir,—I can fully confirm Dr. Trechmann's statement as to the absence of hypersthene from the Carrock Fell rock. Some few years since, feeling suspicious, I had a slide cut from one of two or three specimens in my collection, and saw at once that the mineral was only a form of pyroxene. The hornblende, I conjecture, is of secondary formation, *i.e.* more or less uralite—a change especially frequent in gabbros. As regards the late Mr. Clifton Ward's identification, I have always suspected that he had identified the Carrock Fell mineral with hypersthene by its general appearance (which however is not very characteristic), and not by optical tests. His analysis, with its small quantity of magnesia, shows the improbability of the mineral being hypersthene. Indeed, I doubt whether the mineral has yet been really identified in Britain. Certainly, as Zirkel has shown, and as Prof. W. H. Miller informed me more than ten years since, the ordinary mineral in the Skye hypersthenite is pyroxene. One or two instances have been quoted from Wales, but I do not credit them. T. G. Bonney.

23, Denning Road, Hampstead.

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## ORIGINAL ARTICLES.

### I.—ON SOME REPTILIAN TEETH FROM THE UPPER PERMIAN CUPRIFEROUS SANDSTONES OF KARGALINSK, NEAR ORENBURG, RUSSIA.[1]

By W. H. TWELVETREES, F.L.S., F.G.S.,
Member of the Imperial Society of Naturalists of Moscow, etc.

(PLATE VIII.)

THE teeth under consideration in this paper were derived from the Kargalinsk copper mines in the government of Orenburg, Russia. These mines are in the marls and sandstones overlying conformably the Zechstein or Magnesian Limestone, and were referred by Murchison to the upper division of the Permian. Other writers have regarded them as belonging to the Lower Trias, so that the question of their horizon is still *sub judice.* I have elsewhere explained my reasons for believing them to form part of the Permian formation, and wishing to avail myself of the latest Russian opinions, I have recently asked Dr. Trautschold, the esteemed palæontologist of Moscow, what is the state of opinion now, and he informs me that there are as yet no positive data on which to base a Triassic hypothesis. Dr. Trautschold has visited and examined the locality, an advantage not possessed by many of those who consider the series must be Triassic, because reptilian remains of a high grade are found in them.

The teeth represented in the Plate were found in different mines not far apart. Those of Figures 2 and 3 are from the Roshdestvensky mine belonging to the Voskresensky works, and situate 30 miles north of the town of Orenburg. That of Figure 1 is from an adjacent mine. It is difficult to make much of isolated teeth; but as these are singular forms, it may be useful to rescue them from oblivion by a passing description.

Fig. 1 is a fine canine with a trenchant, minutely crenated posterior border. The crown is invested with the usual coating of enamel, wrinkled in parts. The pulp cavity, as demonstrated by sections, is conical and long, extending to within a short distance of the apex.

The apex shows traces of wear on one side and in front, and from this I should think that a lower canine rose in front of it. In its general aspect the tooth is theriodont and recalls the canine of *Cynodraco major,* Ow. But its crenulation is finer and its central cavity is larger, and at one time I thought its dentinal structure might turn out to be different from that of *Cynodraco*. I imagined that the spots visible on the surfaces of the transverse sections might be vascular canals cut obliquely across in their course to the circumference. Mr. Hulke and Prof. Seeley obligingly pointed out to me that this could not be the case, because the calcigerous tubes are seen to radiate from the centre horizontally, and if vaso-dentinal canals existed, they must run in the same plane.

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[1] Read before the Hackney Microscopical and Natural History Society, June 7, 1882.

Eichwald's *Deuterosaurus biarmicus* is represented by remains from the Upper Permian copper mines of Klioutschefsk in the Bielebee district of the Ufa government. The skull contains teeth differentiated into premaxillaries, canines and molars. The lower canine figured in Eichwald's Lethæa Rossica, tab. lviii. fig. 1, somewhat resembles our tooth, but is more cylindrical, besides being smaller, and no mention is made of any serration of the posterior border. Some confusion exists in the description in consequence of taking the incisors for canines.

The present tooth does not appear to belong to any known reptilian genus from the Russian Permian rocks, and we must consequently wait for the announcement of further discoveries.

*Incisor of Deuterosaurus biarmicus.*—This is shown by Fig. 2 in our Plate. It is a large tooth, with the crown anteriorly elevated into a point, and posteriorly bulging out into a swollen protuberance superficially rugose. On the protuberance the rugæ are furrowed transversely. They pass up and over the top of the posterior part of the crown, subsiding as they approach the acuminate summit, the front and sides of which are smooth. The whole tooth, crown and fang, with the exception of the posterior protuberance, is laterally compressed. Blunt serrations exist along the external edge of the crown, decreasing in size and number in the ascent of the summit. The specimen being broken into two pieces, one can see that a pulp cavity extended backwards and upwards into the post-basal protuberance. The dentinal structure is of the ordinary kind—tubuli radiating from the central cavity. The fang is hollow and its cavity is occupied by the sandstone matrix.

*Supposed Dinosaurian Tooth.*—Fig. 3 is a curved sabre-like tooth, the posterior trenchant edge less curved than the anterior one. A fine crenation prevails all the way down this edge. The anterior border is armed with a similar crenation, which ceases after proceeding down about three-fourths of the crown. This crenation does not follow the median line, but runs parallel to it, and terminates quite abruptly. The enamel is smooth, a little wrinkled here and there, and marked with faint and fine longitudinal striæ. The base of the tooth is hollow. Higher up, the pulp cavity exists merely as a linear trace.

The partial crenation reminds one of Megalosaurian teeth. It is not a character observed in any of the teeth referred to Theriodonts, and is to my mind suggestive of the existence of a Russian Dinosaurian reptile in Permian times. It is a thinner, more compressed tooth than Megalosaurian teeth generally.

Huxley, in his paper on the "Classification of the Dinosauria, with Observations on the Dinosauria of the Trias,"[1] remarks on the Dinosauria of the Urals. He suspects *Deuterosaurus* will prove to be a Dinosaur. This, however, falls within Owen's Theriodontia, as does *Rhopalodon.*

I venture to throw out the suggestion that the tooth now described indicates a reptile of the order *Dinosauria.*

All true reptilian (*i.e.* distinct from amphibian) remains from this formation in Russia which I have seen or heard of are theriodontine. Dinosaurian remains are as yet unknown. The miner is the sole agent we can rely upon for disentombing these Permian reliquiæ. The absence of natural sections in the vast grass-covered steppes, and the reputation which the rocks of this age bear for paucity of organic remains, as well as the knowledge that the few which are derived from them are of a connective character, linking together the Palæozoic and Mesozoic epochs, invest every additional, though isolated, discovery with unique interest.

### EXPLANATION OF PLATE VIII.

FIG. 1*a.* Canine of an unknown Theriodont reptile from Levsky mine, Kargalinsk steppe. 1*b.* 1*c.* 1*d.* transverse sections, 1*e.* crenation of border magnified. I am indebted to Mr. Thos. Rickard for the loan of this tooth.

FIG. 2. Incisor of *Deuterosaurus biarmicus* (Eichwald), from Roshdestvensky mine, Kargalinsk steppe.

FIG. 3. Supposed Dinosaurian tooth from the same locality.

The subjects of Figs. 2 and 3 were generously presented to me by Mr. Mr. Robert Fletcher of Lothbury. All the figures are natural size.

## II.—ON THE ORIGIN OF THE LOESS.

By SEARLES V. WOOD, F.G.S.

VARIOUS theories have been advanced to explain the origin of the Loëss of Europe, Asia, and North America, the latest having been that of Mr. Howorth, in the pages of this MAGAZINE.

Although possessing no knowledge of this formation, outside of England, beyond that derived from the descriptions of those personally acquainted with it, I have for some time thought that the Loëss has originated from an agency of which I detect evidences among those phenomena of the Newer Pliocene period in England which I have endeavoured to trace in detail in a memoir on that subject laid before the Geological Society of London; but as the Loëss in general is not discussed by me in that memoir, I venture to offer a few observations on the subject of it for the consideration of the readers of the GEOLOGICAL MAGAZINE.

It appears to me that in all arctic countries not occupied with land ice, and where therefore the soil is permanently frozen to a great depth, and only the surface for a depth of two or three feet annually thaws, conditions must obtain, of which in temperate latitudes, save so far as the sliding away of an Irish bog may offer a partial parallel, nothing furnishes any analogy.

Although trees and vegetation grow freely during the summer on this small thickness of thawed surface, it is obvious that no water can penetrate the permanently frozen part below, and that the water arising from the dissolution of the snow, and from the summer rain which penetrates this thawed portion, must convert it into sludge; and that having no vertical downward escape, such as that which in climates where the soil is not permanently frozen supplies water to springs, and wells, all escape of the water thus saturating the thawed surface, which evaporation does not account for, must be lateral.

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[1] Quart. Journ. Geol. Soc. 1870, p. 72.

Where the material acted on is porous sand or gravel, this lateral escape may take place without any diplacement of the material itself; but in imperfectly permeable material such as clay, and especially in such perfectly but slowly permeable material as limestone, the latter of which this perennial alternation of frost and thaw must rupture and convert into loam or marl, this escape cannot, I imagine, occur until the material has become so saturated as to be mobile.[1] In that condition its tendency must be to slide from higher to lower positions; and thus, while accumulating in the lower, to uncover and expose in a corresponding degree in the higher positions, more and more of what would otherwise be the permanently frozen portion to this action of alternate thaw and frost.

To this action during the minor glaciation I have, in the concluding part of the memoir referred to, attributed the origin of the "*Warp*" of Trimmer, the "*Trail*" of Fisher, and the "*Landwash or formation of great submergence*" of Prestwich, as well as that amorphous Cave-earth which has in so many cases evidently found its way into the caves through fissures in the rock from the surface above; while to the same but more prolonged action during the major glaciation, I have referred the clay with flints, which covers those parts of the chalk of England which were above the line to which the great submergence that was coincident with such glaciation in this country reached, and were not occupied by the land-ice. Up to that line the waves as the land gradually sunk removed whatever of this formation had previously accumulated, and as the glaciation endured for only the earlier portion of the emergence, whatever formed during that emergence below this line was small in quantity, and insufficient to give rise to such a distinguishable and uniformly distributed material as occurs above it, and which is susceptible of delineation on map.[2] Similarly this action during the minor glaciation has not been sufficiently prolonged to cover the surface in general with any considerable thickness of this material, or else, as England was during that glaciation nearly all in the condition of land, that part of the country of which the surface consisted of material favourable to the action in question would be enveloped by this material, instead of its being for the most part confined

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[1] I propose in a subsequent communication to offer some remarks as to the peculiar material which has resulted from this action upon the chalk with flints, and which is not marl.

[2] It has in fact been mapped by the Geological Survey in parts of Herts and Bucks; and though I am not aware that the Herts portion is published, I have been kindly allowed to examine the MS. sheet containing it.

ecognizable quantity to certain spots, such as the hollows
d by the buried cliffs of the south coast, and only thinly,
rmittently distributed elsewhere.

ıgland, where this formation has resulted mainly from the
n question during the long duration of the major glaciation,
covers the chalk which formed islands above the line of
ın submergence, it begins at the point where the Chalky-clay
he land-ice of which that clay is the moraine having either
e case with the Chalk-wold of Yorkshire and Lincolnshire,)
ɔd the chalk throughout the major glaciation, or (as is the
;h the highest chalk summits near Royston and Baldock,)
l over it during the emergence, and so ground off this
and covered the chalk with that moraine in lieu.

the Loëss of Continental countries appears to me to have
ɔd in this way, and for the most part to belong to that por-
he formation which accumulated during the prolonged rigour
ajor glaciation.

ıch of it as is represented by the "Limon Hesbayen," which
ll Southern Belgium as well as a part of Northern France,
at the line where the Campinian sand ceases, and covers
consider to have been land during the Glacial period or
ɔart of it. This sand, on the contrary, I have in the first
the memoir already mentioned (Quart. Journ. of the Geol.
1880, page 477) referred to the sea which by the great
and southerly depression of England during the major
ın extended over this country generally, from the eastern
it, to which during the Crag it had been confined, so as to
England to a depth which increased westwards to near
ɔt in North Wales, and southwards to near 700 feet in Hamp-
The part of least depression, and where probably this did
;h 300 feet, was North-east Suffolk and East Norfolk; and
depression diminished still more towards Belgium, the sea
more and more in that direction, until the shore of it is
by the line where the Campinian sand terminates, and the
Hesbayen sets in. The region occupied by this sand appears
represent a flat and shallow part of the bottom of this sea,
ıat which extended along the shore of the land at the time
represented by the Limon Hesbayen. This flat bottom as
ıe land during the slow recession of the sea, while the more
engulphed region of England was emerging, also became
with an Eolian formation of Dunes raised by the wind as
receded from the sand of the shore-line as this gradually ad-
from the recession of the sea; for the Campinian sand
to lose its Eolian character downwards, and to pass at bot-
gravel and shingle.[1] The limit of the Limon Hesbayen in
similarly, I think, marks the continuation of this shore line;
ıgh the evidences of this submergence have mostly been
in Northern France, it is hardly conceivable that the sub-

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en Broek, and Cogels, Ann. Soc. Malacologique de Belge, vol. xii. and xiv.

mergence, which reached the elevation at which it is traceable in the South of England, should not have extended some way over the North-west of France; and indeed gravels occur there which appear referable to this, though, as is the case with the South of England, the action of the waves during emergence have removed all but a few patches of such gravel which now remain to show its original outspread on this sea-bottom.

Over the portion of France, therefore, where this submergence extended, the area beneath the line of it would be destitute of this atmospheric formation of the major glaciation, in the same way that the corresponding part of England is; but the similar formation resulting from the agency in question during the minor glaciation would occur there; and this I take to be the limon, or brick-earth, which covers the lower chalk plateaux of Picardy, and which wrapping over the Picardy valley slopes is the same, M. de Mercey says,[1] as covers the *Cyrena* gravel of the Somme Valley, and buries the old Picardy shore-line, that is to say, the shingle and cliff of Sangatte, near Calais, thus corresponding with the material under which the ancient cliffs of Brighton, Isle of Wight Foreland, Portland, and Sili Bay in Glamorganshire are buried, which, like the Picardy limon, is full of angular fragments of flint in the chalk districts, and of other stone elsewhere, due to the shattering effect of intense frost acting on the moisture which penetrates even solid flint.

The Loëss seems to occur throughout all that part of the Northern hemisphere which falls within those latitudes which must have had an Arctic climate during the Glacial period, and through that part only; the molluscan remains which it has yielded being those of land-shells alone. The land-ice from the moraine of which most of the Glacial clays have originated, and which *protected the land surface from the agency in question*, was confined to those regions, such as Scandinavia, Ireland, Scotland, and the Northern part of England, where, though the mountains were of small altitude, they were close to the source of the snow—the Sea, or to those more inland regions where the greater mass and elevation of the mountains caused the fall of greater volumes of snow than the summer sun could remove, and which therefore invaded and overwhelmed the low grounds. Beyond these regions, and embracing by far the larger part of the Europeo-Asiatic continent, were those where the snowfall was less than the summer sun could remove, and consequently no land ice; and here, under the intense Siberian-like climate of the time, the action in question went on. In North America the Loëss extends apparently over the region drained by the Mississippi and its numerous tributaries, and sets in where the evidences of the land ice, which seems to have filled the whole of St. Lawrence and

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[1] Bulletin de la Société Linnéenne du Nord de la France, p. 303. As M. de Mercey describes this limon as reaching from nearly the bottoms of the valleys in Picardy to elevations of more than 200 mètres, and on the plateaux as attaining a thickness of 30 mètres, I infer that part of it, like the clay with flints in England, originated chiefly during the major glaciation on that part of the chalk with flints which was above the line of submergence during some part at least of the period of this glaciation.

Lake basin, and covered the Adirondack Mountains, terminate. This Loëss in the Mississippi valley teems (according to Sir C. Lyell, in Antiquity of Man, p. 237) with land-shells, and occasionally graduates near the rivers into a subjacent and more stratified deposit containing freshwater shells.

I have made these observations as brief as possible, both because my knowledge of the Loëss is limited in the way already mentioned, and because I desire to offer them as tentative only; but I incline very strongly to the belief, now less in fashion than it was, that the explanation of Geological phenomena is to be sought in causes still existing, rather than by resort either to causes wholly supposititious, or only now found to be in action to some very subordinate extent.

## III.—The Loess—a Rejoinder.

By Henry H. Howorth, F.S.A.

WHATEVER the result of this controversy, your readers will not be ungrateful to me for having been the means of drawing from such a distinguished explorer and geologist as Baron von Richthofen, the vigorous defence of his views which appears in the last Number of the Geological Magazine. The admirable work he has done in China it would be an impertinence in me to praise; but I may be allowed to say that a large part of it will outlive any ephemeral discussions about the Loess—discussions in which there must be a considerable element of doubt, whatever theory is adopted. I cordially thank Baron von Richthofen for the kindly terms in which he refers to my writings on the history of the Mongols. Having done so, I would express a feeling, shared perhaps by others than myself, that, when discussing my views about the Loess, which were, I hope, stated in deferential language, it was hardly necessary to adopt expressions which are not quite judicial. The polemical vocabulary of Germany is proverbially somewhat tropical, and seems to some of us to be more adapted to religious and political strife, where feeling plays a large part, than to the dissection of cold scientific facts, where neither authority nor vigorous assertion avails much. Especially is this so in addressing a cultivated audience like that which your pages are likely to reach. If Baron von Richthofen's theory had been generally accepted in the scientific world, a little emphatic dogmatism might be overlooked; but as this is the very opposite of the fact, and the only difference between us is, that while he is a distinguished heretic, I am an obscure one, it seems to follow that the most seemly language for each party to use, especially for the one who has every claim to a wide reputation, is that of sobriety, if not of hesitation.

Turning from the manner to the matter of Baron Richthofen's paper, I confess to being greatly surprised. It is quite true that his work upon China is incomparable in its way, and will become a classic; but he is not the only writer who has dealt with the Chinese Loess after a long and familiar acquaintance with it. Father David, whose admirable papers in the Nouvelles Archives du Museum d'Histoire Naturelle, are very widely known, has travelled over perhaps quite as extensive a tract in China, and has examined the problem of the Loess there with a special view to Baron Richthofen's theory, and has not only written about it, but has written very strongly, as Mr. Kingsmill has, against it; while if we turn to America, where the Loess deposits, the consideration of which I wished to postpone to a later paper, are so extensive, there has been a very wide discussion of the same problem, and with the exception, perhaps, of Mr. Clarence King and Professor Pumpelly, a general consensus of opinion completely adverse to Baron von Richthofen. If authority "*qua authority*" were of any avail in such a controversy, this would be a fair way of meeting the position he maintains; but for one heretic to quote authority against another is not very conclusive. Let us, therefore, brush aside these appeals on either side, and grapple more closely with the problem itself, which is admittedly a very difficult one.

With the first pages of Baron Richthofen's paper I have virtually no controversy. He merely condenses and states in clear tabulated form, what I urged in more diffuse, and perhaps not such clear language. About the twelve characteristic peculiarities of the Loess which he refers to there is no difference of opinion, save in regard to the first and the eleventh, to which I shall refer presently, and I mostly completely agree with the dictum that neither the sea, nor lakes, nor rivers, could deposit the Loess at altitudes of 8000 feet on hill-sides. This was the burden of three-fourths of my paper, which I reiterated more than once, and which seems to me to be incontrovertible.

Again, when the term subaerial is used by Baron Richthofen as covering his position, there must be no mistake about my own meaning. I have no doubt whatever that the Mammoth and his companions, that the land shells and the debris of vegetables found in the tufas, are as clear proofs that the conditions in which they lived were subaerial, as the same series of remains is in the case of the brick-earths and the loams. In all these cases the remains prove the existence of subaerial conditions, and not subaqueous ones, where the animals and plants lived. I believe, further—and the view is fully held both by French and American as well as by our own geologists—that the animal and vegetable contents of the Loess, as well as its stratigraphical position, prove that it belongs to precisely the same horizon geologically as the loams, brick-earths, and the so-called diluvium. All this I have never hesitated to urge. The ground I have taken is, that at the epoch when Palæolithic man lived, there was a tolerably uniform deposit over central and southern Europe, representing the old land surfaces on which the Mammoth and his companions passed their lives, represented as to texture, ingredients, and contents in its most unsophisticated form by our lower brick-earths and the diluvium gris of the French writers. The whole being of subaerial origin, this homogeneous deposit was presently sophisticated in two ways. When the catastrophe came—which I have adduced a very considerable array of evidence to show closed the Mammoth period and formed that notable gap which is universally acknowledged by archæologists between Palæolithic man from Neolithic man, the loams were largely redistributed and rearranged, remaniés as the French call it, while at the same time there was an outpouring of a considerable amount of subterranean mud in certain districts, which was mixed with the subaerial surface deposits, and with the debris of animals and plants then living on the surface, and thus constituted the Loess. The Loess, therefore, in this view, is a subaerial deposit sophisticated and altered by a flood of calcareous mud or water charged with mud, and distributed as we find it by an impelling wave of water. It will be seen, therefore, that the question between us is not as to whether the deposit is subaqueous or subaerial, but whether the particular subaerial theory of Baron Richthofen and the peculiar atmospheric agencies appealed to by him are competent to explain the constitution of the Loess and its distribution; and if not, whether the subterranean origin of a large portion of it is possible, and whether its distribution by a flood of waters is not an hypothesis which more completely explains the facts.

Baron Richthofen complains that I did not quote directly from his book. That most valuable book, which I looked through some time ago with mingled admiration and envy, was certainly not by my side. I have not a copy of it, nor is there, unfortunately, a copy of it available for reference in these parts; but I appeal with every confidence to your readers, who may examine the Baron's restatement of his case, whether I either mis-stated or misunderstood it. It will be conceded by those who do so examine it that every point of any importance he now urges was perfectly present to me when I wrote, and was, as I think, fairly met. On the other hand, it seems very clear that Baron Richthofen has only read one paper out of a considerable series which I have contributed to your pages, all of them aiming at one conclusion, all of them supporting one thesis, and whose force, if they have any, depends on their cumulative character. Perhaps, if he does me the great favour of replying to this communication, he will first look over the papers which preceded and have succeeded that dealing with the Loess.

The first point to which I would call attention is that we are completely at issue about the kind of surroundings which the debris of the Loess fauna show must have existed when that fauna was living. Baron Richthofen says, "The genera and mostly the species of mammals found in the Loess, or their next relatives, are known to abound at present in steppes and on grassy plains." Is this so? The Mammoth, it has been well said, would starve in a few days on the richest Craven pasture. The Elephant and his nearest relatives cannot browse upon the herbage of steppes or grassy plains. Its natural habitat is the forest, its natural food — the succulent branches of trees, and we actually know, as is most familiar to Baron Richthofen, that both the Mammoth and the *Rhinoceros tichorhinus* did live upon the softer portions of trees, for remains of their food have been preserved and examined. These are *the characteristic* quadrupeds of the Loess, and with them occur other forest animals. If we turn from the mammals to the molluscs in the Loess, the very large proportion of which are land shells, the same conclusion is inevitable. Those conchologists who are best able to decide such a question agree that the Helices and other shells of the Loess lived in the recesses of damp woods, and their abundance proves the conditions to have been singularly favourable to them, namely, those of a humid atmosphere and of deep shade.

I have quoted European authorities for this view whose experience is overwhelming. Let me add to them that of my correspondent, Prof. Todd. Speaking of the abundance of land and the paucity of aquatic shells in the American Loess, he says: "However, some semi-aquatic species, as *Succineas* and *Helicinas*, are very abundant from top to bottom of the formation, and the decidedly aquatic *Limnea humilis* is quite abundant in the Upper Loess of Western Iowa. This is sufficient to show that the formation, so far as this region is concerned, could not have been so dry as is called for by Richthofen's theory. Even the land shells observed need a much moister region than our upland prairies in their present conditions. Some of them are not found at all, away from moist banks or groves." Again, "I think no one can study the life of the Missouri Loess without seeing that it bears, throughout, evidence of a moist climate, the very opposite of the Baron's ideal."—(Richthofen's Theory of the Loess, by J. E. Todd, p. 6.)

The evidence of the mammals and shells is supported also by the debris of vegetation in the tufas, which prove the former existence there of luxuriant forests. All this is entirely at issue with the Baron's postulate, and in fact cuts the ground from beneath it. I referred to it in my paper, but he does not notice it in his reply.

The existence of thick moist woods is assuredly inconsistent with the dry winds and dry grass pastures which he requires for his theory, inconsistent also with the prevalence on any scale of those dust-storms which he postulates, and perhaps the best proof of this is that while the Loess is such an exceedingly fertile soil, in North China, where *local* dust-storms prevail largely, nothing is more remarkable than the virtual absence of trees over many degrees of latitude—a circumstance which the Père David has made much comment upon.

We have not yet done with the fossil contents of the Loess. In certain places, as we have urged over and over again, the remains of the animals are found intact, showing that they could not have been transported very far. In other cases they are found buried in hecatombs. In others again, and most frequently, the bones are found sporadically and much scattered. In all cases, as we have tried at very considerable length to show, they present evidence of having been largely disturbed and transported. How could such agencies as the Baron invokes explain the presence of great hecatombs of animals buried pell-mell together, or the presence in some cases of whole skeletons of Mammoths and Rhinoceros, or explain in others the dispersal of their bones. All these factors are inconsistent with continuous gentle atmospheric agencies only and with the accumulations of vast depths of Loess through which the bones are distributed irregularly, and I must repeat that I cannot conceive how the wind could transport them or the dust bury them intact, unless the meteorological conditions were entirely different from those now in existence, and quite transcendental.

Let us now turn to the structure of the Loess. Baron Richthofen accepts the theory which makes the ramifying calcareous tubes found in the Loess to be the root impressions of grasses, and bases a good deal of deduction upon it. The theory that they are so, and are not due to calcareous filtration, is at present, however, very much in need of evidence, and, to my mind, has utterly collapsed. I would add to what I said on this subject in a previous paper, that if these tubes were mere casts of roots, we ought assuredly, in regard to a *forest* flora, to find any number of casts of *tree* roots, and roots of *herbaceous* plants, which are so easily discriminated; but we find none of these—only the ramifying fine tubes which have been called grass roots, but which, to my mind, have nothing whatever to do with grass roots, but are due to the percolation of water charged with calcareous matter. This is further supported by the fact that they do not occur where the Loess has a dense hard structure—only where it is porous; that they occur chiefly near the surface, and diminish in size as we go down, which is the exact result we should expect from percolating threads of water acting on a deposit highly charged with carbonate of lime, and inconsistent with a deposit gradually growing higher, while the plants, whose roots the tubes are supposed to be, were continuously being buried by additions of wind-borne dust. In regard to the features just named, Mr. Todd (who, by the way, does not question their being root-marks) says: "They may be said to vary inversely as their distance below the surface. Near the surface, besides being most abundant, larger ones are found. At the depth of 30 or 40 feet, they are very minute and rare. None have been found lower than about 45 feet, although several favourable localities have been examined" (Todd, *op. cit.* p. 8).

The concretions that occur in the Loess add very considerably to the weight of evidence which makes these tubes to be the results merely of percolating water, for these concretions are clearly the result of the same agency acting slightly differently. In regard to these concretions, I shall be pardoned for quoting a graphic description by my correspondent, Prof. Ellsworth Call. He says: "They assume all possible shapes from the spherical through the spheroidal to the oblong; in all cases they are more or less numerously studded with roughened projections. No one shape seems to obtain more than another, and not unfrequently several are found cemented together, forming an eccentric single mass. They are certainly characteristic of the Loess, for that formation nowhere occurs without their presence. *They are decidedly hydraulic, as would be naturally inferred from their constitution.* In no case have I ever observed fossils—either mollusks or vegetable matters—acting as a nucleus. On one occasion 2803 of these bodies were crushed with that especial point in view. In nearly every instance, 2789, they were found to contain loose fragments broken by some means from their inner walls, but no foreign substance whatever could be detected. In the remaining 14 specimens, while the concretions were hollow, they yet contained loose particles of no substance whatever. Not a single specimen was solid throughout. *That they were originally solid, or of a pasty consistency, is not to be doubted, as a study of the inner surface reveals. They all present a deeply fissured interior consequent on the evaporation of water and subsequent contraction.* In the vast majority of cases the pyramidal masses of the interior showed distinct irregularly concentric lines of growth, or rather of accretion. . . . . Professor J. D. Whitney says of them that they '*have been formed in the Loess by infiltration along the lines of cleavage and resultant chemical action on calcareous matter occurring in large quantity along certain planes*'" The Loess of North America (American Naturalist, May, 1882, pp. 373 and 374). To return to the tubes. I see no evidence whatever in them to support the wind theory of Professor Richthofen, nor do I see any either in the peculiar quality of the Loess, by which it cleaves in perpendicular faces, which is no doubt due to the presence of calcareous matter in excess, and to the presence of these very tubes. Wherever we can trace current and unmistakable wind formations, such as dunes, etc., etc., we have no such cleavage properties, and I cannot see how Baron Richthofen proposes to connect them with his predicate.

Again, the Loess for the most part is completely unstratified. Occasionally, especially in America, there are local areas where a kind of stratification occurs. but these are very local, and I shall return to them presently. This absence of stratification I quoted myself as a proof that the Loess is neither of marine, lacustrine, nor fluviatile origin. It is assuredly equally a proof that it is not due to gradual accumulation by the wind. Dunes accumulated by the wind are so easy to study that we have no difficulty in finding materials, and assuredly they present quite a different structure to Loess. Deposits made by wind, especially when made as Baron Richthofen suggests, in dry seasons alternating with wet ones, have a laminar structure corresponding to the series of layers deposited, just as deposits made by water have. Nor should we find homogeneous masses several hundred feet thick with the same structure and the same contents as the results of such *a series* of seasonal deposits. These masses, to my mind, bear, on the contrary, unmistakable evidence in their very structure of having been deposited by one great effort, and under one set of conditions. Again, wind acting upon dust or sand, deposits it with a very well-marked contour in dunes and sand hills, especially when the sand is arrested by grasses (*a fortiori* by forests of trees), and forms great masses of rolling sand hills on the weather-side of any area subject to sand drifts. Where are such phenomena to be traced in the structure of the Loess deposits? No doubt, in certain localities where the wind has recently and is even now disturbing the surface layers of Loess, we get such wind structure; but this is purely local, and to be explained as just mentioned.

Professor Aughey speaks of this wind-structure in some of the Loess hills on the Logan, Elkhorn, Loup, and Republican rivers. He says, "This structure is often found there as distinct as among the shifting sands of our sea-coast. In every case, however, where I examined this structure in the Loess, I found it to be superficial. Out of nineteen such hills none of them possessed this structure over ten feet deep, and few of them over five feet, and many of them only from two to three feet deep. In the deep cañons, where the Loess is exposed vertically from one hundred feet, I have never found this wind-structure over ten feet deep. It occurs, therefore, only in the Loess that has been recently modified by winds, and long after it was first deposited" (Sketches of the Physical Geography, etc., of Nebraska. p. 274). It would be difficult to find a more striking proof that the Loess was not originally distributed by the wind than the fact that it so readily assumes a wind-structure, and yet that this peculiarity is only traceable in the superficial layers where the current winds have acted upon it. Again, wind driving dust and sand in a definite direction, as, for example, from the Mongolian steppes towards China, would, in crossing such a broken district as the long tract of mountains bordering the valley of the Yellow River on the north, leave unmistakable traces of its passage. It would strip the high ground completely and choke up the valleys, especially those parts of the valleys under the lea of the mountains; but nothing of this sort, if we are to follow the careful observations of Père David and others, occurs; but the Loess is generally deposited in a mantle, as one American writer says like a blanket, washed evenly over the surface, and not piled up in drifts in those places where the force of the wind could not move it. Again, such a wind would assuredly sift the materials, dropping the heavier ones first, and carrying the lighter ones further away; but this is not what we find, the texture is the same throughout, and throughout, heavy grains of quartz and particles of mica occur confusedly among the finer siliceous dust, as Baron Richthofen himself says. Again, the process described by the Baron would surely rub down the particles of dust by trituration against one another, and make them rounded and weathered, whereas, as he has remarked in China, and other observers in America, a remarkable feature of the Loess is the sharp-edged and angular particles out of which it is formed.

Baron Richthofen explains the Loess as composed partially of dust brought in by winds and partially as the result of the decay of grasses and other vegetable matter. The proof of the existence of these grasses he finds in the calcareous tubes we have mentioned. But apart from the reasons we have urged against the capillary tubes being treated as casts of roots, upon which a good deal of the reasoning in regard to the vegetable debris in the Loess depends, we must remember that the various analyses that have been made, especially of the American Loess, show that there is hardly a trace of carbonaceous matter in it—assuredly a very strong proof that the amount of material due to decayed vegetation in the Loess is hardly appreciable. This is true also of the black earth of Russia, and is in very marked contrast with the beds of real humus intercalated with the Loess in certain places (see Aughey, *op. cit.* p. 176).

No doubt in Mongolia we have a high plateau covered with thin grasses, and no doubt thin grasses will arrest moving dust. This is a mere parallel to the office performed by the various siliceous grasses in forming the dunes and sand hills of Holland; but the sand itself in Holland comes ready made, and, as I understand Baron Richthofen, the surface of the Gobi is formed of Loess ready made, the grass merely arrests it in certain places when it is moving, it does not help to make it. What we want to know is, how and where it was or is being made either formerly or now. Let us now turn to the European deposits of Loess. Whence did the wind bring them? They were clearly not made *in situ* by the wind acting on the drift deposits and gravels underlying the Loess. Whence then did they come?

If we turn east, west, north, or south of the great area of European Loess, whence are we to derive the dust which formed its basis according to Baron Richthofen? Wind blowing over grass pastures takes no dust—it must be over bare ground; but where are we to find such anywhere? Again, if all the grass of the Russian or French plains was taken off, Baron Richthofen will not argue that wind blowing over the ordinary loam known as diluvium or over the chernozom would carry off dust which, when deposited, would be Loess. All this surely demands some answer, as does the cardinal problem, that the Loess is a limited deposit in Europe with sharp boundaries, especially towards the north. I can nowhere find an answer to this critical question in Baron Richthofen's paper. Suppose we could find such a source for the dust, still our difficulties would not be ended; for the problem, as solved by Baron Richthofen, requires that we should have quite exceptional conditions besides. Take, for example, the demands upon our credulity involved in the following sentence in his own paper: "The Loess-covered portions of Europe extend, as is well known, from the Pyrenees, the Alps, and the Balkan in the south, to Belgium, the North German plains and Poland in the north, and from southern France in the west to beyond the limits of the continent in the east. Every portion of this entire region must have had the character of a steppe during a sufficient length of time to allow the deposit to be formed in at least such thickness as we observe at present" (*op. cit.* 301). Where have we any evidence to support such an extraordinary postulate? Where is the evidence that this large portion of Europe was a dry grassy steppe when the Helices and other damp-loving molluscs were living here? These and the debris of plants in the tufas are very much better tests of the climatic conditions than hypothetical appeals to a continental climate induced by Europe being prolonged as far as the hundred fathom line, as if the presence of sea shells mingled with those of the land, and with Mammoth remains, at the mouth of the Somme, and at several points on our own coasts, do not prove such a postulate to be out of the question at this particular epoch. In Europe, therefore, so far as we know, there is no area whence the dust could come, and there is abundant evidence that the dry steppe-climate of Baron Richthofen is virtually out of the regions of possibility. But he makes still greater demands on our faith when, not content with speaking of a steppe climate, he speaks of such steppes as if they were the equivalents of or had any analogy with the Siberian tundras, and treats the two as if they were the same thing. The tundras are as different to steppes as anything can be; they are covered with thick moss, and can neither be denuded by winds nor have their substance increased by them. They are essentially exceedingly humid, and quite different to the dry areas he otherwise speaks of. Surely we require some explanations of these extraordinary statements. Here let me say parenthetically, that Baron Richthofen cannot be serious in urging that the proof of the identity of the Pleistocene fauna of Europe, including that of the Loess, with that buried under the tundras, was reserved for Dr. Nehring. Has he forgotten the name of Cuvier, to select only a very big name from a large crowd, who proved this elementary position long before Dr. Nehring was born? Nor assuredly can he be serious in supposing that when the Fig, the *Cyrena fluminalis*, and the Hippopotamus lived in Europe, the climate here was like that now current on the lower Obi and Yenissei. If he really urge this, in view of all the facts and the matured opinions of the Russian naturalists which I have brought together in the earlier papers of this series, then I have nothing more to say.

Baron Richthofen postulates two climatic conditions as having succeeded one another in regions where Loess prevails, one marked by extreme dryness, the other by great damp. How is this shown, when both the fauna and flora point to a damp climate having existed at the time when Baron Richthofen demands a very dry one? But apart from this, we are reasonable in asking for some foundation upon which to rest such meteorological revolutions in such areas as China, the valley of the Mississippi, and Central Europe. It is easy to postulate a humid climate following a continental one, in which the conditions were almost the reverse of each other, so long as we limit ourselves to possibilities of *thought*; but we, who are morbidly anxious for some reasonable explanation of our difficulties, must have something more than transcendental predicates. We must have inductive ones. I know that local dust storms in North China do prevail, as they prevail in Mongolia and in North America, where the Loess exists; but, as Professor Call says, the evidences of such action are purely local, and dust storms merely tend to rearrange the surface, denuding the windward, and covering more deeply the leeward, bases and sides of the hills; but these winds do not help us to explain either the origin of the Loess or its general distribution.

There is no evidence that the dust from the Mongolian steppes is now adding to the Loess which occurs in China, which is separated from Mongolia by the well-known chain of mountains that runs north of the Yellow River. But suppose it were, we should be no nearer solving our problem; for Baron Richthofen urges that the

Loess is not being stripped from Mongolia, but is growing there too, as it is in China. How, again, can we understand a patch of steppe, in the centre of a vast area of Loess, supplying all the country round with dust, while it is being stripped itself by all the winds of heaven? for we must remember that the Russians have shown that in the province of Irkutsk, north of the Gobi Desert, Loess occurs as it does in China. The problem of deriving the main body of the American Loess from the small area known as the American Desert would be equally great, even if it were proved that the ingredients of the Loess were ready there for these winds to act upon. Again, I must urge what seems to have escaped Baron Richthofen, that it is quite clear from every consideration that the Loess belongs to the same geological horizon as the diluvium of the French and Russian writers. The contents, animal and vegetable, and the primitive works of man which it contains, as well as its stratigraphical position, all prove this. Again, although the Loess differs from the loams and brick-earths in its texture, and in the abundance of carbonate which it contains, yet its mode of distribution, as we have shown, is essentially the same, both being spread over high ground and low, irrespective of the drainage, and being otherwise similarly distributed. Any theory that accounts for the distribution of the Loess must also therefore explain the idiosyncrasies of the loamy deposits. Assuredly the wind theory of Baron Richthofen would even by himself be deemed incompetent to explain the difficulties of the brick-earths and upland loams of Western Europe. Prof. Aughey urges an objection which is closely connected with this. He says very properly, that "a fact often overlooked is the transition character of some beds of sand as they shade into the Loess. As beds of Loess and stratified sands at the bottom of Loess sections often alternate, and even sometimes with strata of clay, it is not easily conceivable how subaqueous agency should have formed the one, and æolian agency the other" (*op. cit.* p. 280). Lastly, Baron Richthofen argues as if all the debris found in the Loess were subaerial. This is not so, however. In America, in China, and in Europe it is quite true that the land shells prevail largely over the water shells; but the latter are certainly found in appreciable numbers, especially in the Loess of Iowa, showing that considerable lakes or rivers must have existed, which is again proved by the traces of stratification in certain areas. I think the American geologists exaggerate the extent of these lakes from overlooking the fact that the Loess has been largely transported and rearranged, and thus its contents have been swept over a wide area remote from their original site; but it is nevertheless absolutely clear that evidence of such lakes exists, and such lakes in fact exist still.

In Clay, Fillmore, York, and other counties, says Professor Aughey, "there are considerable numbers of ponds, covering from a few acres to half a section of land, grown up around the border with reeds and coarse grasses and sedges, and, where the water is deeper, with arrow leaves, pond-lilies, and other water plants. In every instance where I had an opportunity to examine them, there was a thin bed of clayey matter mixed with organic materials, from a few inches to a foot or more in thickness, lying on the bottom, and on the top of the Loess deposit. This clayey matter was probably deposited there before the waters finally retired from the old lake bed in which this soil originated" (*id.* pp. 270 and 271).

How is it possible to account for such sheets of water under the arid conditions absolutely required by Baron Richthofen's fierce winds and steppe climate? The fact is, whichever way we approach the problem, it seems to me that Baron Richthofen's theory not only fails to explain the facts, but is completely at issue with them. His great name may give the theory a certain ephemeral importance, but it will not bear the test of close criticism when we leave the realms of general hypotheses, and come down to the grim, awkward, tyrannical region of facts, and when we have turned it over in every way with one result, we confess to feeling that there is some temerity in its author speaking of the *exposé* he has given in your pages as refuting without any further discussion arguments which are not even touched.

Having said so much about the Baron's theory, I must now turn to the justification of my own, which he characterizes with scant courtesy as "views which could be pronounced at an early and rather low stage of geological science, but are long since abandoned," "suppositions which bear the character of the infancy of that science," and of which he says again that he does not believe that any geologist will seriously take the trouble to argue against. I must at once disabuse him of this view. If he had seen the letters on my table from those whose reputation is not less than his own, he would not have used these phrases, which are rather characteristic of the amenities of scientific controversy of a former day. I can assure Baron Richthofen that, whatever the value of the views, they have certainly secured the attention and received the approval of those whose judgment I respect, and that they will need to be met by some stronger arguments than those he has so far used.

When it seemed clear to me that the Loess could not be explained as a marine, lacustrine or fluviatile deposit, and that Baron Richthofen's view was equally inadmissible, it was necessary to frame some new theory which would meet the facts. These were an explanation of the origin of the Loess, and secondly of its distribution. In regard to its origin, I suggested that it seemed to have great analogies with the Moya or volcanic mud that is thrown out in certain volcanic districts, and that its calcareous ingredients seemed to point to a subterranean origin. Baron Richthofen says dogmatically that the Loess differs completely in composition and structure from all known kinds of volcanic mud, ancient or modern. This is a strong assertion, and if it be indisputable, it goes some way to discount what I have said. Now it is very strange that a few weeks after my papers on the Loess were printed, I received a letter from Professor Aughey, of Nebraska, calling my attention to the important fact that in Nebraska, where the Loess is developed on the largest scale of any district in America, it is found in close connection with the so-called geyser deposits of the American geologists. Speaking of the Pliocene beds of Nebraska, he says, "Near or in many of these beds all over the Pliocene region of the plains are found many extinct geyser tubes, and sometimes old geyser basins. Of these I observed at least thirty between Arapahoe and the west line of the State; I have also found them in the Loup region, and on the Niobrara. As some of these geyser tubes had their exit in the Fort Pierre group on the Upper Republican, it is probable that they commenced their work in the Cretaceous period, and were in operation all through the long centuries of the Eocene, Miocene and Pliocene periods, *and far into the Quaternary*; a similar bed exists on Oak Creek, which was deposited in interglacial times. Nebraska and Northern Kansas, in fact, was a great geyser region all through the Tertiary period. It far exceeded in the number and magnitude of its geysers the Upper Yellowstone region and Iceland at the present day. Few memorials of these old extinct geysers are visible at the present time, owing to their being covered up by the superincumbent Quaternary deposits, but enough remains to show that a prodigious number must have existed at least in Pliocene times" (Sketches of the Physical Geography, etc., of Nebraska, pp. 239 and 240). If we examine the analyses that are available of the Loess from different districts of the silico-alkaline earths that characterize the Nebraska Pliocene beds and of geyserite proper, we shall be constrained to assign them all three to the same ultimate cause. This evidence is surely very important, and it will, I trust, in some measure affect Baron Richthofen's emphatic statement which I have quoted. I showed in my paper that in the European area of the Loess, calcareous springs, fumes of carbonic acid, and other traces of still living volcanic action exist, while the proofs that they existed much more forcibly during the deposition of the Loess are very familiar, the intercalation of Loess and volcanic ashes in the Rhine volcanoes being the most forcible. This I have already shown at some length in a previous paper. In regard to the mountains of North China, which are the focus of the Loess deposits there, I might quote many additional facts from Père David's papers already cited, in which he has shown how in all directions these mountains are strewn with evidences of volcanic forces actively at work down to the most recent geological period, and apparently showing special signs of activity in the Quaternary period.

It will be remembered that in postulating a subterranean origin for certain ingredients of the Loess, I did so in a very hesitating way, and merely as a tentative hypothesis. Tentative hypothesis only it still remains, as does every opinion I hold upon every subject; to be surrendered immediately, and without regret, directly it is shown to be inconsistent with the facts. At present, however, so far as my judgment goes, it is the only hypothesis available, for the only process that I know by which siliceous mud consisting of very comminuted angular particles entirely free from structure, and from the presence of foraminifera, etc., charged with carbonates, and like the Loess in every respect, can be explained, is the theory I have offered. Nay, more, as I have shown or tried to show, the only method by which deposits very like the Loess are at the present moment being made is by the very process I postulate, of which Baron Richthofen writes so lightly. So much for the origin of the Loess. In regard to its distribution I do not speak with the same hesitation. Here the evidence, as I have presented it to your readers, is so consistent, cumulative and overwhelming, that it will require a very great many *facts* on the other side to disturb it. The evidence that the Loess was spread over the country independently of the drainage—spread like a sheet over hill and dale by a mass of moving waters—is so great that it seems to me conclusive. I have tried to focus a portion of it, as well as the evidence of the correlated deposits and their contents, from many quarters. The proofs are at present ample, that the big mammals were actually drowned, that they perished not singly but in many cases in hecatombs, that they were immediately covered over and protected from the weather in some cases with their skeletons intact, in others with their bones scattered hither and thither, that the loamy deposits wherever we meet with them and however we sift them bear unmistakable traces of this great wave of waters, which is amply supported again by the ethnographic evidence and by human tradition. This and much more *ejusdem generis* I have partially tried to show in the papers I have printed in the MAGAZINE, and which are not yet concluded. The nature and extent of this diluvial movement, which Baron Richthofen produces as a scarecrow, I cannot discuss at present nor until a good deal more of my evidence is published. At present it will suffice to say that I believe it was very widespread in the Northern Hemisphere, and that one of its notable effects was the origin of the Loess by the mixing of the products of a subterranean flood of calcareous mud with the loams forming the land surface where the Mammoth lived in the areas now covered by Loess in Europe, China and America.

I hope Baron Richthofen will forgive any expressions which he may disapprove of in this paper. It is not to be expected that phrases wanting in courtesy can be used by a distinguished writer of one very much his inferior without some resentment. He would not respect me if I consented to such treatment. But I can assure him, if I may be guilty of the presumption, that no one from Cathay to Peru rates more highly than I do his reputation, nor values more his contributions to Eastern Geography and Geology, and no one awaits more impatiently the time when they may be published at a cost that will bring them within the reach of poor men—poor men living in Philistia — overloaded with books and babies, and only very moderately endowed by nature with those qualities that secure success in the struggle for existence.

I wish to add a postscript on another matter on which Baron Richthofen could perhaps help me; or perhaps my appeal might reach some other German geologist. In the fourth volume of Middendorf's Travels, p. 1081, there is a very extraordinary account of the discovery of a Mammoth which, if reliable, is valuable. The notice has been partially translated in one of Professor Dawkins' papers, and again in his Early Man in Europe, p. 106. This notice has always seemed to me to be most suspicious. It describes how a young German engineer in the Russian service called Benkendorf, being one day in a steam launch in the estuary of the Lena, came across a Mammoth which had been detached from the frozen banks of the river, and was careering about in the flood. The notice describes how the animal was secured by a rope, how it was examined, and the contents of its stomach observed, but that presently a sudden rush of water carried it away. The whole story is told in a vigorous style, and with a very suspicious resemblance to a romance concocted out of what was already known about the Mammoth, and in fact adds little of actual fact to our previous knowledge. I recently looked up the notice in Middendorf, who quotes the account as trustworthy, but I confess my suspicions were not allayed when I found whence he had obtained it. He quotes the story from a boy's book entitled "Kosmos für die Jugend. Blicke in die Schöpfung der Welt und in die Kulturgeschichte der Menschheit vom anfang bis zur Gegenwart," published at Nurnberg in 1862, and written by Philipp Körber, the author of many other works. This book I have not been able to consult, as, unfortunately, like many others, it is not in the British Museum Library. The account professes to be taken from the letter of the young Russian naval officer Benkendorf, who was born in the Island of Oesel in the Baltic, February 23rd, 1821, and joined a topographical expedition to Siberia, whence he wrote several letters to Körber describing his adventures, the one we are interested in being in the year 1846. It is very strange that if genuine no accounts of this discovery should have reached the ears of Baer or Brandt, Schmidt or Schrenck, who none of them mention it, and that it should be first heard of in a popular book for boys in 1862. It would be interesting if the story could be sifted by some one who could get access to Mr. Körber, or even to his book, and the information would be especially useful to students like myself.

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## IV.—SUPPLEMENT TO A CHAPTER IN THE HISTORY OF METEORITES.

By WALTER FLIGHT, D.Sc., F.G.S.

(*Continued from page* 316.)

### Found 1879, July 19.—Lick Creek, Davison Co.[1]

In this paper is given an engraving, actual size, and a short account of a small metallic mass, weighing rather more than two pounds, and found at the above date in Davison county. When found it was covered with a thick scaly crust of oxide. It weighs 1·24 kilogrammes or 23¾ ounces avoirdupois. It is one of the rare class that do not show the Widmanstättian figures. It contains iron, nickel, cobalt, and phosphorus. A complete analysis of the meteorite is being prepared. It is the property of Professor W. E. Hidden, of the New York Academy of Sciences. Mr. Hidden has in his cabinet three other undescribed meteorites from the

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[1] *Illustrated Scientific News*, New York, March 15, 1880, iii. No. 6, pp. 62 and 66. *mer. Journ. Sc.* xx. 1880, 324.

Southern States, one of which weighs 1·45 kilogrammes, or 32½ oz. avoirdupois.

### 1879, November 4.—Kalumbi, Wayee (Wai, Jaluca), Sattara, Presidency of Bombay, India.[1]

Brezina records the presentation to the Vienna Collection of a piece of a meteorite weighing 165 grammes by Mr. M. Wood, of the Bombay Branch of the Royal Asiatic Society. The fall occurred at the above place and date, and the stone has the form of a four-sided wedge, with a nearly square base. Its weight is 10¼ lbs. and 197 grains, and its density is 3·45. According to an incomplete analysis, 58·75 per cent. was insoluble in hydrogen-chloride (consisting of silicates, and the silicic acid of the decomposed portion), and, in addition, there was iron oxide, or rather iron protoxide with alumina 27·62, nickel 1·56, lime 0·83, and magnesia 11·88 per cent. The meteorite resembles Forsyth, has a light yellowish ground-mass; the chondra are firmly inclosed in the ground-mass, and for the most part white and felspathic. This stone is to be classed with the white chondrites.

### 1880, February 18, early in the Morning.—Kuritawaki-mura, Yosa-no-gori, Tango, Japan.[2]

An eye-witness of the fall of this stone states that in the early morning he was washing his face, when he saw a ball of fire cross the sky from north-east to south-west. He was much astonished when a small stone fell before him from the sky. He caught it up and found it was very hot, and gave forth a smell like that of gunpowder. The stone is about 1½ inches long and three-quarters of an inch wide, and weighs about 100 grains Troy. It is completely covered with a hard black glaze. It appears to be a stone and not a meteoric iron.

The same correspondent mentions a meteoric stone of large size, preserved at Toji, which is said to have fallen from the heavens in ancient times; and reports another at Chionin. He also says: "I learn that a stone of several pounds weight fell at Tamba a few years ago."

The same number of the *Japan Gazette* contains a short reference to another aërolite. The mineral stone which fell some time ago at the front of a gate of Iwata, of Takeda-mura, Yabe-gori, Tajima, with a brilliant light and report, is about 1½ *sun* thick and 9 *sun* in circumference, and weighs about 200 *momme*. This stone has been sent to the Bureau of Agriculture of the Home Department, and will be investigated by Prof. Kinch.

### 1880 (early in).—Colorado Basin, Ivanpah, Southern California.[3]

This block of iron was found in the Colorado Basin, within eight miles of Ivanpah, which is about 200 miles north-east of San

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[1] A. Brezina, *Sitzber. Akad. Wiss.* 1880, lxxxii. Oct. part.

[2] *The Japan Gazette*, April 19, 1880.

[3] C. U. Shepard, *Amer. Journ. Sc.* 1880, xix. 381.

Bernardino in Southern California, by a Mr. Goddard, who while crossing a *wash* had his attention arrested by a singular-looking boulder. The block is oval in shape, having a side somewhat flattened; its surface is covered with depressions and dents, as if it had been pelted all over with pebbles while soft or plastic. These concavities are from 1 to 4 inches across, and, in addition, there are three round holes an inch deep, as if made by the little finger. The mass is supposed to weigh 120 lbs., and it is 14 inches long, 9 inches broad, and 7 inches deep. The examination of a fragment shows it to be highly crystalline, requiring no etching to reveal the Widmanstättian figures; the cleavage appears to be octahedral. The schreibersite is very thin, and, according to Shepard, of two kinds: one in flat leaves, the other in wavy semi-cylinders or irregular prisms; the latter, he says, may be the rhabdite of Reichenbach. The density of the iron is 7·65, and its composition:—

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|---|---|
| Iron ... ... ... ... ... ... ... ... | 94·98 |
| Nickel .. ... ... ... ... ... ... ... | 4·52 |
| Phosphorus ... ... ... ... ... ... ... | 0·07 |
| Graphite ... ... ... ... ... ... ... | 0·10 |
| | 99·67 |

## 1880, May (first half of).—Karand, 12 miles east of Teheran, Persia.[1]

The fall of a meteorite which was actually seen to descend, and which is not an event of every-day occurrence, deserves, on account of its mineralogical interest, some notice. It is not possible here to ascertain with certainty the constituent minerals; it is therefore possible at present only to give a short sketch of the stone; later on, when we have the material to work with and the help of an authority in this branch, we may return to the subject. In the first half of the month of May, 1880, we were called before the Shah, who handed to us a metallic shining mineral, weighing about 400 grammes, which, from the outer crust still adhering to it, we at once recognized as a meteorite. We saw that the Shah took the shining metal in it for silver, for he asked the value of it. But when we spoke of the iron, and its probably containing nickel, and that the mineral had more scientific than intrinsic worth, it was permitted to us to take the stone away, and to break off a piece for closer examination.

The Shah made himself acquainted with the origin and cause of meteorites, and informed us that the stone in question weighed 45 kilogrammes, and fell in the neighbourhood of the village of Karand, twelve miles east of Teheran, with an explosive noise like thunder.

Half of the stone was covered with a thin, blackish, fused crust, while the fresh lustrous fractured surface showed it to have formed a portion of a much larger stone. A fragment weighing 3·66 grammes was found to possess a density of 4·36. The fractured surface showed a grey, passing into green ground-structure, with, in places, single pieces of an oil-green mineral, with a lustre of glass, probably olivin. In the mass lay, closely strewn together, small and large granules of white iron; also little plates of this metal lay inclosed in it, and violet-blue tinted grains, similar in their play of colour to copper pyrites.

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[1] Mining engineer Ferd. Dietzsch, in Teheran; in a paper intituled 'Geologisches Berg- und Hüttenmännisches aus Persien,' in *Berg- und Hüttenmännische Zeitung*, March 18, 1881.

The pulverized mineral is pretty light, and almost entirely soluble in hydrochloric acid. The fractured surface was covered in a few days with a thin oxidized crust, although some portions of it are as fresh after five months as at first.

In his note on this meteorite Brezina[1] states that the fall took place at Veramin, in the month of April, not May. He received a fragment from Baron Gödel-Lannoy, Secretary of the Legation at Teheran; the portion which Dietzsch received appears to have been lost. Brezina's piece weighs about 16 grammes, the meteorite itself weighs 20 to 25 kilogrammes, and is preserved by the Shah in a garden. This stone, it appears, belongs to the rare group of mesosiderites, of which but two members, Barea (1842) and Estherville (1879), have been seen to fall. The remaining members of this group, Niakornak (1856), Hainholz (1856), Janacera Pass (1860), Newton Co. (1860), Sierra di Chaco (1862) and Sierra di Deesa (1865), have no crusts. The Persian stone has a fused crust of a lustreless, granular, dull grey colour, with, in places, rusted spots; it closely resembles that of Daniell's Kuil (1868), it is exceedingly thin, from 0·05 to 0·08 mm. On the freshly-fractured surface the Persian stone bears the greatest resemblance to that of Newton Co.; numerous crystals of olivine, some 2 mm. in diameter, in one case a mass 7 mm. across, are inclosed in a highly crystalline groundmass, which appears to consist for the most part of olivine.

### 1880. Found in May.—Lexington County, South Carolina.[2]

A mass of iron, weighing 10¼ lbs., was found at this locality, in May, and sent to the Shepards, father and son, for examination. It has the form of a cylinder with two flattened edges; the surface is nearly free from yellow hydrated peroxide of iron, being mostly enveloped with a black and brittle coating, which, though containing some troilite, is yet almost entirely formed of magnetite. Amygdaloidal masses of troilite, of the size of filberts, are met with. Magnetite and graphitoid are found coating the troilite. The Lexington iron closely resembles the Bohumilitz iron, found in 1829, and preserved at Prague, especially in the two etched surfaces: they, in fact, are the only two which strikingly show the *moiré métallique* lustre; the crystalline bars in the Lexington iron are nearly twice as large as those in the Bohemian specimen. The included spaces are filled with extremely minute lines of tänite, crossing each other at all angles from 90° to 150°. Its density is 7; that of homogeneous fragments being 7·405, and that of the troilite 4·77. Analysis showed it to consist of:

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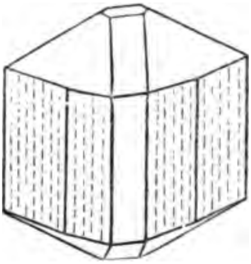
[1] A. Brezina, *Sitzber. K. Akad. Wiss.*, 1881, lxxxiv. July part.

[2] C. U. Shepard, *Amer. Jour. Sc.* 1881, xxi. 117.

| | |
|---|---|
| Iron | 92·416 |
| Nickel | 6·077 |
| Cobalt | 0·927 |
| Insoluble matters | 0·264 |
| Tin | a trace |
| Phosphorus | a trace |
| | 99·684 |

### Meteoric Deposits on Arctic Snow, off the Taimur Coast, 1880.[1]

Immediately after the "Vega" lay-to, Baron Nordenskjöld went down on the ice, in order to see whether here too some such metalliferous dust, as he had before found north of Spitzbergen, was not to be found on the surface of the ice. Nothing of the kind, however, was to be seen. On the other hand, Lieutenant Nordquist observed small yellow specks in the snow, which he collected and handed over for investigation to Dr. Kjellman. Nordenskjöld supposed that the specks consisted of diatom ooze. After examining them Dr. Kjellman, however, declared that they did not consist of any organic substance, but of crystallized grains of sand. Nordenskjöld too examined them more closely, but unfortunately not until the morning after we had left the field, and then found that the supposed ooze consisted of pale yellow crystals (not fragments of crystals), without mixture of foreign matter. The quantity of crystals, which were obtained from about three litres of snow, skimmed from the surface of the snow on an area of at most 10 square mètres, amounted to nearly 0 2 gram. The crystals were found only near the surface of the snow, not in the deep layers. They were up to 1 mm. in diameter, had the appearance shown in the accompanying woodcut, and appeared to belong to the rhombic system, as they had one perfect cleavage, and formed striated prisms terminated at either end by truncated pyramids. Unfortunately actual measurements of them could not be made, because after being kept for some time in



Form of the Crystals found on the Ice off the Taimur Coast. Magnified thirty to forty times.

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[1] A. E. Nordenskjöld, The Voyage of the "Vega," vol. i. pp. 327-331, Macmillan, 1881.

the air they weathered to a white non-crystalline powder. They lay, without being sensibly dissolved, for a whole night in the water formed by the melting of the snow. On being heated too, they fell asunder into a tasteless white powder. The white powder that was formed by the weathering of the crystals was analyzed after our return,—21 months after the discovery of the crystals—and was found to contain only carbonate of lime.

The original composition and origin of this substance appears to me exceedingly enigmatical. It was not common carbonate of lime, for the crystals were rhombohedral, and did not show the cleavage of calcite. Nor can there be a question of its being arragonite, because this mineral might indeed fall asunder "of itself," but in that case the newly-formed powder ought to be crystalline.

Have the crystals originally been a new hydrated carbonate of lime, formed by crystallizing out of the sea-water in intense cold, and then losing its water at a temperature of 10° or 20° above the freezing-point? In such a case they ought not to have been found on the surface of the *snow*, but lower down on the surface of the *ice*. Or have they fallen down from the inter-planetary spaces to the surface of the earth, and before crumbling down have had a composition differing from terrestrial substances in the same way as various chemical compounds found in recent times in meteoric stones? The occurrence of the crystals in the uppermost layer of snow and their falling asunder in the air, tell in favour of this view. Unfortunately there is now no possibility of settling these questions, but at all events this discovery is a further incitement to those who travel in the High North to collect with extreme care, from snow-fields lying far from the ordinary routes of communication, all foreign substances, though apparently of trifling importance.

Baron Nordenskjöld then refers to the metallic particles found by him on the snow during previous years (see GEOL. MAG. Dec. II. 1875, Vol. II. pp. 157–162), and says in conclusion:—

It may appear to many that it is below the dignity of science to concern one's self with so trifling an affair as the fall of a small quantity of dust. But this is by no means the case. For it is estimated that the quantity of the dust that was found on the ice north of Spitzbergen amounted to from 0·1 to 1 milligram per square mètre, and probably the whole fall of dust for the year far exceeded the latter figure. But a milligram on every square mètre of the surface of the earth amounts for the whole globe to five hundred million kilograms (say half a million tons)! Such a mass collected year by year during the geological ages, of a duration probably incomprehensible by us, forms too important a factor to be neglected when the fundamental facts of the geological history of our planet are enumerated. A continuation of these investigations will perhaps show, that our globe has increased gradually from a small beginning to the dimensions it now possesses; that a considerable quantity of the constituents of our sedimentary strata, especially of those that have been deposited in the open sea far from land, are of cosmic origin; and will throw an unexpected light on the origin of the firehearths of the volcanoes, and afford a simple explanation of the remarkable resemblance which unmistakably exists between plutonic rocks and meteoric stones.[1]

## V.—ON SOME POINTS IN ANGLESEY GEOLOGY.

By R. D. ROBERTS, M.A., D.Sc., F.G.S., Clare College, Cambridge.

IN my former short communication on this subject, I referred only to the question of the age of the quartz conglomerate at Nebo, which Dr. Callaway mistook for a part of the granitoidite series, but which Prof. Hughes has shown to be Cambrian conglomerate. What Dr. Callaway says in reply may be seen at page 287. The second point which I stated I should deal with later, I now take up. Dr. Callaway wrote (GEOL. MAG. 1881, p. 423), as follows:—

"The altered rocks of Anglesey, the 'metamorphic Cambrian and Silurian' of the Survey, are shown by a variety of evidence to be older than the Cambrian. Rocks of precisely the same mineral character, showing the same order of succession, and lying on the same strike, are sometimes coloured by the Survey as 'Cambrian,' sometimes as 'Silurian.' True Cambrian and 'Silurian' strata do indeed occur in many parts of Anglesey, *and they have given their name on the map to the metamorphic rocks which happened to be near them* (the italics are mine); but *in no case* are there any signs of a transition between the altered and unaltered beds." Turning to the Survey map of Anglesey, it is seen that the northern part of the island is coloured and named "altered Cambrian," the southern boundary of which is a curved line running in a general east and west direction representing a supposed fault, where black shales are in juxtaposition to so-called altered Cambrian. From Dr. Callaway's own words just quoted, especially those italicized, I am bound to conclude that he applies the term metamorphic to this so-called "altered Cambrian"—a part of the "gnarled series" of Professor Hughes. My criticism upon the above was simple. I wrote (GEOL. MAG. 1881, p. 573), that if Dr. Callaway in penning the words "in *no case* are there any signs of a transition between the altered and unaltered beds," had in view the gnarled series occupying the northern part of Anglesey, I differed from him, because at two spots I had observed a passage between the black shales and the so-called "altered Cambrian."

Dr. Callaway replies as follows: "Dr. Roberts discusses the contorted rocks of northern Anglesey, which he affirms Dr. Callaway has included under the head metamorphic. Again we have, 'This area of so-called metamorphic rock,' and that his readers may be thoroughly impressed with my error, he further on reiterates, 'which Dr. Callaway has included under the head Metamorphic,' and more to the same effect. All this is pure error." I have simply taken the plain and obvious sense of Dr. Callaway's words, and I would ask any one to read the words quoted at the beginning of this communication from Geol. Mag. 1881, p. 423, then look at the Survey Map of Anglesey, and see if any possible conclusion could be drawn other than the one I drew, viz. that Dr. Callaway accepted the term metamorphic, or altered, as applying to the patch of northern Anglesey coloured "altered Cambrian."

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[1] Namely, by showing that the principal material of the plutonic and volcanic rocks is of cosmic origin, and that the phenomena of heat, which occur in these layers, depend on chemical changes to which the cosmic sediment, after being covered by thick terrestrial formations, is subjected.

Dr. Callaway denies that a true passage occurs. We differ therefore on a matter of observation, which can only be settled in the field. I have only one more quotation to make from Dr. Callaway's paper. He says: "I will content myself with stating that when Dr. Roberts has *thoroughly* explored the island, he will find that the Cambrians contain fragments derived from the 'gnarled series.' This will place him in rather an awkward dilemma." I was already aware that gnarled fragments occur in *some of the conglomerates*, but I am placed in no dilemma, for I did nothing more in my former communication than state certain observed facts. Various explanations have suggested themselves, which as yet, however, have hardly taken definite enough shape to be called even working hypotheses.

## REVIEWS.

I.—Life, Letters, and Journals of Sir Charles Lyell, Bart. Edited by his Sister-in-law, Mrs. Lyell. 2 vols. pp. 475 and 489. With Portraits. (London: John Murray, 1881.)

It is no exaggeration to say that Lyell did more than any other man to advance geological science. Others there were who helped much more than he to solve special enigmas concerning the origin or relation of rock-masses, to unravel the structure of particular districts, or to interpret the life-history of the past; in personal eloquence, too, he was not unsurpassed; but in enthusiasm, and in the interest he took up to the last in the discoveries bearing on his favourite science, he yielded to none, while in literary ability he was unequalled among his geological contemporaries.

The labour of his life was his "Principles of Geology; or the Modern Changes of the Earth and its Inhabitants, considered as illustrative of Geology." His work commenced at a time when the science was looked upon as entirely a record of the past, and not merely of past times but of past agents, for it was considered that the forces now at work were not at all competent to produce the changes so plainly evidenced in the earth's crust. Lyell's work clearly established the fact that the present is but the continuation of the past, unbroken by any universal gap or catastrophe; and although the strictly uniformitarian lessons that have been drawn from his works are to some extent modified now, yet his method of explaining geological changes, is continually corroborated by the advances made in geographical knowledge.

The life of one who worked such a revolution in geological thought, as did Lyell, is calculated to attract all votaries of the science. His early years were spent in the New Forest, where his father, a man of independent means, resided for some time, and to whose literary and scientific tastes the son owed his bent of mind. Born in 1797, he went to Oxford at the age of eighteen, where an interest in geology was aroused by the lectures of Buckland; and from this date his attention seems to have been given more and more to the subject.

As early as 1817, when staying with Mr. Dawson Turner, F.R.S., at Yarmouth, Lyell became much interested in the recent changes that have taken place in the coast-line of Norfolk—a county to which he returned again and again, and which perhaps thus early served to direct his attention to the particular subjects which afterwards occupied so much of his life. On this excursion he also became interested in the great pear-shaped flints, then recently described by Dr. Buckland under the name of Paramoudras.

These memoranda we gather from letters addressed by Lyell to his father, and the work now before us is chiefly composed of letters from Lyell to his father, his sister, his father-in-law Leonard Horner, to Murchison, Mantell, Sedgwick, Scrope, Herschel, Darwin, Sir Charles Bunbury, and others. In addition to these, we have an autobiography of his earliest years and school-life; his journal of a tour in France, Switzerland, and Italy in 1818; and journals addressed to Miss Horner, and afterwards (when she became his wife) to Lady Lyell. Prefixed to each chapter is a brief summary of the leading events in Lyell's life; and with these and a few other trifling exceptions, Lyell tells the whole story of his life, so far as it is contained in these volumes. The plan thus adopted gives the work a very miscellaneous character; we have remarks on Slavery, Education, the Division of Property, the Indian Mutiny, and various branches of science, as well of geology. Here and there we have reminiscences of distinguished individuals, such as Cuvier, Mrs. Somerville, Babbage, Prince Albert and other members of the Royal Family; as well as of many geologists in whom we take more especial interest. The letters tell the story of Lyell's life so far as its more prominent features are concerned, and they indicate the many subjects which permanently or temporarily engaged his attention. We should have been glad, however, to hear a little more about the surroundings of his life, of his method of carrying on work, and the reception his works received; of the part he may have taken in the great controversies of the time, such as that on the Cambrian and the Silurian question, and on the Antiquity of Man. Some brief account of Lyell's addresses to the Geological Society might have been given, as also of his classification of the Tertiary strata, and the part he took in recommending the establishment of the Geological Survey. But while we thus venture to point out these omissions, we ought not to be the less grateful to the lady who has edited the work with such evident care, and who probably had not the materials to supply all the wants we have noted. Moreover, we must not forget that the history of geological progress is in great part told in Dr. A. Geikie's Life of Murchison, and in his earlier Memoir (partly in conjunction with George Wilson) of Edward Forbes; in Prof.

Phillips' Life of William Smith, and in the Letters and Extracts from the Writings of J. Beete Jukes. To these works, as well as to the one before us, we look for the reminiscences of Fitton, Mantell, Buckland, De la Beche, Conybeare, Horner, Lonsdale, Greenough, Phillips, Scrope, and other distinguished geologists, the story of whose lives is unwritten, and some of whose principal works, unlike those of Lyell, are hidden in the uninviting pages of Journals and Transactions. The life of Sedgwick, spoken of by Lyell as the "first of men," we hope ere long to receive from his able successor in the Woodwardian Professorship.

We have for the most part to form our own opinions of Lyell's personal characteristics from his letters. Originally intended to follow the legal profession, he was called to the Bar in 1825, and went the Western Circuit for two years, but this he relinquished, and devoted his time almost entirely to his aim of furthering geological science. The current of his life seems on the whole to have flowed very easily: he had no struggles to maintain his existence, time and money were at his command, nor had he any children to disturb the repose of his household.

The later letters contain many allusions to the Darwinian Theory, which will be read with interest. But as early as the year 1827 he "devoured Lamarck," saying, "His theories delighted me more than any novel I ever read, and much in the same way, for they address themselves to the imagination. . . . I am glad that he has been courageous enough and logical enough to admit that his argument, if pushed as far as it must go, if worth anything, would prove that men may have come from the Ourang-Outang. But after all, what changes species may really undergo!"

The dinners at the Geological Club are mentioned in several places, and serve to show that brethren of the hammer can be genial as well as scientific. At one gathering, in 1823, Prof. Oersted (of Copenhagen) remarked, much to the amusement of the company, 'Your public dinners, gentlemen, I do love, they are a sort of sacrament, in which you do beautifully blend the spiritual and the corporeal!!'" Again, in 1831, Lyell says, "I had a hard task yesterday to keep my resolutions of severe temperance, for Murchison was so unwell, that he asked me to preside at the Geological Society club dinner, and take his friend Colin Mackenzie to it; so I was obliged to push about the bottle, and to sham taking a fair quantity of wine." Another cheerful meeting he mentions in 1838, when "After the aniversary evening [of the Geological Society], Lord Cole pressed me so hard to go and eat pterodactyl (*alias* woodcock) pie at his rooms, that I went, with Whewell, Buckland, Owen, Clift, Egerton, Broderip, Hamilton, Major Clerk, Lord Adair; and there we were till two o'clock, fines inflicted of bumpers of cognac on all who talked any 'ology.' Cigar smoke so strong as half to turn one's stomach. I lost the enjoyment of Murchison's dinner next day, and for five days did only a half day's work or less."

Lyell was President of the Geological Society in 1836 and 1837, and also in 1850 and 1851. In 1857 he was again invited to take the chair, but refused. Writing to Mr. Horner (from Lausanne) he says, "My taking the office a third time is out of the question. I have done a fair share of that duty, and hope to continue for years travelling, making original observations, and above all going to school to the younger, but not, for all that, young geologists whom I meet everywhere, so far a-head of us old stagers, that they are familiar with branches of the science fast rising into importance which were not thought of when I began. Such is the case with young Gaudin here, a fossil botanist, who in age might almost be my grandson."

The letter on p. 281, vol. ii. is misplaced. Its real date is 1838, not 1858, for it refers to Darwin's paper on the connection of certain volcanic phenomena, and on the formation of mountain-chains and volcanos, read before the Geological Society in March, 1838. In this letter Lyell says, "I was much struck with the different tone in which my gradual causes were treated by all, even including De la Beche, from that which they experienced in the same room four years ago, when Buckland, De la Beche, Sedgwick, Whewell, and some others treated them with as much ridicule as was consistent with politeness in my presence."

The index to the volumes is meagre: there are no references to the Geological Society or Geological Club, frequently mentioned in the Letters, and insufficient references to the individuals whose names are noticed. It is also to be regretted that the list of papers and works by Lyell, forming Appendix E, has not been carefully prepared. The titles are sometimes inexact and the references seldom complete. The important paper by Lyell in 1840, On the Boulder Formation, etc., of Eastern Norfolk, is referred to the "GEOLOGICAL MAGAZINE"! instead of the "Philosophical Magazine."

The variety of scientific subjects touched upon in Lyell's Letters illustrates in one sense the great scope of Geology. And his wide grasp of the subject, aided so much by extensive travel in America as well as in Europe, enabled him to appreciate the results of the labours of so many different workers on the Natural History and Physical Geography of the Earth, not merely of past times, but of the present day.

The task of keeping pace with geological progress was in Lyell's early days comparatively easy, but as the literature of the subject gradually increased it naturally outgrew his ability to keep up with it. Every year, indeed, added to this difficulty, so that in his later years he leant largely on the support of others, who furnished him with the general results of scientific work in different departments—work which he could appreciate and utilize in the grand fabric he had done so much to construct, and in which his interest never flagged.

Shortly after his death, a brief notice of Sir Charles Lyell appeared in the GEOLOGICAL MAGAZINE for March, 1875 (pp. 142–144), from which we quote the following passage:—"He had lived to see the extension of science, which he had so eagerly desired, realized. In future times, wherever the name of Lyell would be known, it would be as that of the greatest, the most philosophical, the most enlightened geologist of Great Britain or Europe."

## II.—NOTES ON VOL. II. OF THE "TRANSACTIONS OF THE SEISMOLOGICAL SOCIETY OF JAPAN."

THE July to December, 1880, volume of the Transactions of the Seismological Society of Japan contains five papers of considerable value, to wit:—Notes on the Recent Earthquakes of Yedo Plain and their effect on certain buildings, by J. Milne; On Pendulum Experiments on the summit of Fujiyama for the purpose of ascertaining the force of gravity at that point, by Prof. T. C. Mendenhall; The effect of Railroad trains in transmitting vibrations through the ground, by Prof. H. M. Paul; On a new Seismograph for Horizontal Motion, by J. A. Ewing; The Peruvian Earthquake of May 9th, 1877, by J. Milne. It will be seen that the founder of the Society, as we believe we may call Mr. Milne, is the principal contributor.

His first paper—the first also on the list—occupies thirty-eight of the ninety-eight pages which contain the reading-matter of the volume. His second paper—the last of the five—an interesting contribution on the Peruvian Earthquake of 1877, fills forty-eight pages.

Mr. Milne's notes on the "Recent Earthquakes of Yedo Plain" commence with a short *résumé* of the work of Mr. W. S. Chaplin and Mr. E. Knipping on the subject of those terrestrial spasms which are a source of such constant and "tremulous" interest to residents in this beautiful island. Mr. Chaplin's reasoning would seem to establish that the moon has no influence in providing earthquakes. His observations and those of Mr. Knipping have been condensed by the author, who has added a catalogue of the earthquakes which have occurred between 1872 and 1881 inclusive, the record being for the most part taken from the registers of the Yamato Yashiki Observatory. This tabulation should be very valuable for purposes of reference. It shows that in nine years from 1872 to 1880 the troublesome number of 370 earthquakes has been recorded. Of these the greatest number, seventy-four, occurred in the last year. In 1878 there were seventy-one earthquakes: in 1874 only eight. Of the grand total, the large majority of 213 made themselves felt in winter, the balance of 157 having been perceived in the summer months. It is only justice to 1881 to say that its seismic department showed signs of considerable energy in the five months of its existence with which the table deals. In that brief period there were thirty-five seisms. Mr. Milne deals at some length with the direction and origin of recent earthquakes, and concludes that, "taking all things into consideration—although some of the earthquakes which from time to time alarm us may have their origin near the volcanos of the interior,—until by instrumental observation something definite has been determined, I should be inclined to think that a large proportion of the shocks we feel have their origin in faulted districts of the south."

The most interesting part of Mr. Milne's paper is that which deals with the effects produced by earthquake shocks upon buildings. An examination made by him of a very large number of brick tenements of similar construction in the capital shows that the faces of such as are situated in streets running S.W. to N.W. have been much more cracked than those in streets at right angles to this direction. His tabulation of the earthquakes also shows that the S.E. to N.W. direction is the one most frequently followed by seisms, which, again, are of greater intensity on this than on any other line of their travel.

Our author has devoted special study to the cracks which earthquakes have made in the houses in Tokiyo. He is sufficiently painstaking and enthusiastic in his investigations to have marked and dated the ends of some of the chinks and watched their progress, earthquake by earthquake, even as the husbandman watches the growth of his crops. Sometimes they would not "grow," however; but our ingenious seismologist set them to work vertically. In other words he placed "indicators" across them, thus discovering that, when they did not increase in length they vibrated—opened and shut their mouths as it were, and told the tale of their own undoing. Following a very fair line of induction, the Professor asks whether it would not be admissible to erect buildings with cracks or joints in them ready made, so that the portions of a structure which are likely to have different periods of vibration may oscillate freely, and independently of each other. Some such plan is already followed, we believe, in the construction of many chimneys in Yokohama, which are built clear of the roof, and thus, it is thought, will not be overturned by the movement of the walls acting on the stacks. If we are not mistaken, some such system as that suggested by Mr. Milne has already been adopted by a French architect, who has done a good deal of work in Japan, building among other places the new offices and godowns of the Mitsu Bishi Company in Yokohama. Much of Mr. Milne's paper should be valuable to those who are concerned in the erection of tenements, of whatever kind, in Japan. For instance, he points out that archways which join their abutments at an angle are more likely to crack than such as *curve* into the supports.

The second paper of the series is a very short one by Professor Mendenhall on pendulum experiments on the summit of Fujiyama for the purpose of ascertaining the force of gravity at that point. It is, we believe, an abstract of a long treatise published in the scientific memoirs of the Kobu Dai Gakko. Although, at first sight, the subject may appear to be foreign to seismology, yet closer examination shows that it is one of considerable interest to the followers of Palmieri, inasmuch as it deals directly with the internal nature of one of the most famous of volcanos—Mount Fuji. Taking the density of the earth, as established by the work of other observers, Professor Mendenhall shows us how it is possible to calculate backward, and determine the density of Fujiyama, on the top of which by the swinging of a pendulum the scientist determined the force of gravity at that point. From the results of the work, it would appear that the body of the mountain has about the same density as is suggested by observation of the rocks which are found on its surface. Had the mountain been left very hollow at the termination of the series of eruptions which formed it, its density would have been much greater than Mr. Mendenhall's experiments have proved it to be.

Mr. Paul contributes the abstract of a treatise on the effect of Railroad trains in transmitting vibrations through the ground. This paper is extremely interesting in conveying an idea of the immense distance to which earth vibrations may be transmitted. The object of the investigation which is chronicled by the writer was to determine a site for a United States Naval Observatory, where observations could be conducted without serious interference. The brief abstract published by the Society merits full citation. We have only space, however, to say that, by observing through a powerful telescope the surface of mercury lying in a dish placed at a mile's distance from him, the experimentalist at his post on a railway line can note the effect of the vibration of a passing train upon the subtle mineral, as accurately as if he were peering into the vessel itself. This wonderful telescopic feat almost eclipses the fact that it demonstrates, namely, that the earth's surface is sufficiently elastic to transmit comparatively the small vibration caused by a passing vehicle to a great—perhaps to an indefinite—distance.

Professor Ewing's paper, the fourth in the volume, is an abstract of one read before the Asiatic Society in December, 1880. It describes a seismograph which appears to have been constructed with scientific accuracy and to have done good work in recording the tremors which it has experienced.

The fifth and last paper is from the pen of Professor Milne, and is on the great Peruvian earthquake of May, 1877. It contains a tabulation of all the phenomena connected with a series of abnormal sea-waves which swept across the Pacific in the month in question, and the effects of which were slightly experienced in the harbour of Yokohama, and further north, as at Hakodate, where it did considerable damage. A sea-wave, originating in seismic spasm, takes about twenty-five hours to travel from South America to Japan. But electricity rides still more speedily; and it might be well for the Government of Japan to make arrangements with the controllers of the South American Republics to telegraph hither prompt accounts of seismic or volcanic disasters which may occur in their vicinity.

Mr. Milne has introduced into his essay a series of calculations whereby he estimates the point (between Pabalon de Pica and Iquique, and nearer the former than the latter place) where the great earthquake originated. As several of the methods employed by the writer in his attempts to locate the point of origin of terrestrial disturbances appear to be new and at the same time perfectly rational, this portion of the treatise will probably prove a valuable addition to the science of seismology. The writer also makes some notes on previous earthquake-provoked waves which have crossed the Pacific in this direction, with calculations of the Ocean's depth, whereon, it must be remembered, depends, in a great degree, the velocity of wave movement. His calculations made on many observations indicate that the profundities of the sea are much less than those given by actual soundings. In short, theory and practice are, as usual, at variance; and, of course, Mr. Milne holds that in this case *practice* is at fault. Sooth to say, his proposition (that, in deep sea soundings, owing to the continuous running out of the line, after the lead has touched the bottom, it is very hard to determine the depth with accuracy) seems sound enough. He concludes his contribution with a paragraph on the importance of systematic tide observations in Japan, which he holds, if properly made and recorded, would be of great service not only to the hydrographer and navigator, but also to the physicist and geologist.

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## III.—ÉTUDE STRATIGRAPHIQUE ET PALÉONTOLOGIQUE DES TERRAINS JURASSIQUES DU PORTUGAL. Par PAUL CHOFFAT. Première livraison: Le Trias et le Dogger au Nord du Tage. 4to. pp. 72, with local sections. (Lisbon, 1880.)

THE subject of Portugal cannot fail to be of interest to the fellow-countrymen of Daniel Sharpe, whose researches, published in the Proceedings of the Geological Society of London for 1839, and in the Quarterly Journal for 1849, laid the foundations of its Mesozoic geology. The value of Sharpe's work is cordially acknowledged by the author; and, though M. Ribeiro, in a series of publications dating from 1852, has found it necessary, whilst paying close attention to the Jurassic series, to make material alterations, especially in Sharpe's stratigraphy, his work must be always regarded as something more than the flying visit of an amateur geologist.

On comparing the zones of the Lias with those held to obtain in the rest of Europe, the author notes the absence of the zone of *Avicula contorta*, and probably of the zone of *Am. planorbis*: a different development, or perhaps the absence of the whole of the base of the Sinémurian: a partial and different development of the zones of *Am. Davœi* and *Am. Ibex*: a different development of the Toarcian, at least in the upper part, corresponding to the base of the Bajocian of Oppel. He places the zones of *Am. opalinus* and *Am. Murchisonæ* with the Toarcian, though suggesting that some day the whole may be classed with the "Dogger," or Brown Jura. The absence of the above zones is not due to gaps in the series, the sedimentation appearing to have been continuous.

For him the "Dogger" commences with the zone of *Am. Sowerbyi*, and comprises a good thickness of marly and white sub-oolitic limestones, including the Bajocian, occasionally the Bathonian, and the "Callovian." Throughout the whole of this series corals are rare. The principal fossils are Cephalopods, Brachiopods, and Echinoderms. Lamellibranchs are moderately plentiful, whilst the lists show few Gasteropods.

The most noteworthy circumstance is that where the Bathonian is absent, it is replaced by the Callovian, which comprises much more than the mere equivalents of the Kelloway rock, including in fact what we should call the Cornbrash, and a large portion of Oxford Clay. The characteristic Ammonites are there, with the exception of the *ornati*, and this group, in places, succeeds the *Parkinsonii* zone of the Bajocian.

Contrary to expectation, part of the Portuguese Jurassic presents a strong analogy with that of the Anglo-French basin, but in the south the Alpine facies predominates. A very curious and complex subject is that of the relations between the northern and the Alpine facies. At page 56 he gives a sketch-map of their respective limits from the Atlantic to the Tyrol, as shown in the several formations. The lines run approximately N.E.—S.W. Several measured sections, sometimes illustrated by rough diagrammatic cuts, constitute a sort of appendix to the work, which will readily commend itself to all interested in tracing the various phases of development which the Jurassic beds present in Western Europe. W.H.H.

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### IV.—The County Geognosy and Mineralogy of Scotland. By M. Foster Heddle, M.D., F.R.S.E., etc., Professor of Chemistry in the University of St. Andrews.

At intervals, during the last four years, there have been published in the pages of the Mineralogical Magazine several instalments of a remarkable work, which appears to us to have especial claims upon the attention of British geologists. In this work, which is entitled "The County Geognosy and Mineralogy of Scotland," Prof. Heddle (the eminent chemist and mineralogist of the University of St. Andrews) proposes to perform for the whole of Scotland what was so brilliantly accomplished by Maculloch for the Hebrides and the Western Highlands. In his preface, however, Prof. Heddle modestly defines his work as a chronicle of the present state of our knowledge of the *mineralogy* of the northern portion of the kingdom, and proposes to treat of the *geognosy* and *lithology* merely to such an extent as to explain the position of the minerals themselves.

Prof. Heddle has so long been recognized as the first of living Scottish mineralogists, and his familiarity with the minerals and mineral localities of his native land is so unrivalled, that such a work as the present comes most naturally from his hands; and he has accomplished his task so far with a fullness and thoroughness that is worthy of himself and his subject. Each county (commencing at the extreme N. of the British Islands) is taken up separately, its general geognostic and lithological features sketched in outline, and its chief minerals and mineral localities, etc., discussed at length. The minerals themselves are arranged in the order of the geological formations which yield them, and figures and complete analyses of the more important or interesting forms given in much detail. The work is illustrated also by a series of coloured geological maps, in which the main geological and lithological features of the several districts described are laid down.

Eight instalments of the work—embracing the counties of Orkney and Shetland, Caithness, and Sutherland—are already in print, and from these the probable nature and calibre of the work may easily be inferred.

The purely mineralogical portion of the work must be left to the criticism of the professed mineralogist; of its thoroughness and value there can be but one opinion, and the memoir is probably destined to be the standard guide-book to the mineralogical localities of Scotland for many years to come.

But as geologists, those parts of the work which treat of the geognosy and geology of the regions described deserve an especial notice from us, and that not only because of the new data they afford, but also from the bold and novel speculative views they contain. Small as is the area hitherto described by the author, he has already broken loose from many of the accepted traditions, and has enunciated some of the more advanced views of the newer geological schools to an extent that must be startling—to say the least—to those who hold that the British geological scale is complete, and that the Highland rocks are nothing more than metamorphosed representatives of the Silurian sediments of the south. Two instances of this may here be pointed out.

In the concluding portion of his description of the Shetland Isles, the author, after expressing his general accord with Prof. Sterry Hunt in his well-known generalization that "in altered rocks, the crystalline minerals which are formed may, perhaps, to a certain extent, become to the geologist, what organic remains are in the unaltered rocks—a guide to their geological age and succession," enunciates the opinion that the metamorphic rocks of Shetland "form a group which occurs nowhere else in the northern division of the kingdom." He sees in Dr. Sterry Hunt's Upper *Huronian* System a system singularly accordant with the rocks of Shetland, and throws out the hint that the schists of Clova and Portsoy form another series equally accordant with the *Taconian.*

In Sutherland—the queen of Scottish counties—Professor Heddle is at his best. Its magnificent scenery, its remarkable mineralogy, and, above all, its unique geological features, seem to have aroused all his interest. He devotes two successive instalments of his work to a description of this county alone. In the first of these, the scenery of the region is described and discussed with the pen of an enthusiast. In the second an extended account is given of its varied geological formations, from the basal hornblendic gneiss of the west to the micaceous gneisses of the interior. As respects the relation of the Hebridean gneisses and the Torridon Sandstone, Prof. Heddle agrees generally with his predecessors. As regards the presence of the quartzites in the Assynt district, and of intercalated dolomitic limestones and marbles, which are succeeded above by the Sutherlandshire gneiss, he agrees substantially with Murchison and Geikie, but adds largely to our previous knowledge of the local distribution of these rocks. In the matter also of the so-called *igneous rocks* he is in general accord with the last-named observers, and adduces so many instances of intercalation that it is almost impossible to avoid the conclusion that we have here a series of contemporaneous volcanic sheets. But as regards the relation between the fossiliferous limestone of Durness and the unfossiliferous limestone of Assynt, Prof. Heddle's ideas are wholly revolutionary. He shows by several analyses that the Durness and Assynt Limestones are very distinct in chemical composition, the latter being a typical *Dolomite*, containing about 45 per cent. of carbonate of magnesia, while the former is an ordinary *Limestone*, containing only about 3½ per cent. of magnesian carbonate. Several other distinctions between the two limestones are pointed out, and the author contends that these two rocks, hitherto united by all investigators, are totally distinct in geological age—"Different in composition, different in structure, pregnant with fossils, more highly metamorphosed, associated with newer rocks, altogether out of place,—it will need absolutely new evidence before our theoretical geologists are warranted in declaring this (Durness) *Limestone* to be a chip off that old block of (Assynt) *Dolomite*, which now stands above it. And if the two 'Limestones' be different, then the whole fabric of Murchison's correlation of the rocks which overlie the Dolomite falls to the ground."

To this sweeping conclusion the average reader of Prof. Heddle's work will probably oppose the very natural suggestion that, although the Durness fossiliferous Limestone may not be the exact counterpart of the Lower or true Dolomitic Limestone of Assynt, as hitherto believed; yet it may perhaps be the representative of the *Upper* Assynt Limestone—the Ledbeg *marble*: which, as Dr. Anderson has shown (pp. 315 and 316), agrees almost exactly in chemical composition with the Durness bed, and is placed by Dr. Heddle himself in the Quartzitic series, between the igneous rocks and the Upper Gneiss: and if this be the case, the argument of Murchison and Geikie stands unaffected.

This suggestion, however, again lands us in some awkward difficulties, and the new school of Archæan geologists may well draw encouragement from the fact that the two most eminent chemists on opposite sides of the Atlantic, who have largely devoted their own special science to the study of matters more or less connected with geology, should have so strongly pronounced in favour of their views. And when the history of their anticipated Highland conquest comes to be written, Prof. Heddle and his bold and brilliant contributions to the controversy will hold a prominent and honoured place therein. Even the peaceful students of the gradual development of geological discovery, who look upon this conflict from a distance, and watch the alternate successes of the opposing forces of long-established authority, and pre-conceived theory, cannot but feel grateful to Prof. Heddle for having taught them that the Highland question is a vastly greater problem than it appears from a distance. It appears impossible to resist the conclusion that when the subject is attacked earnestly in the good old-fashioned way of mapping every foot of the disputed ground, and allowing the facts to speak for themselves, the sequence will eventually be found to be "clear and simple, and quite analogous to those of other mountain regions," and that when all the evidence is before us, this old mountain region, like that of the Alps themselves, will, even in its difficulties and anomalies, afford another and a "most triumphant proof of the value of the old long-established principles of British geology."

We have hardly left ourselves room to speak of the valuable maps which illustrate the work of Professor Heddle. They are all carefully lithographed and coloured, and will be found of great service to the mineralogical student and collector. Two of these maps, those of the Shetland Islands and of the County of Sutherland, are more than ordinarily ambitious. The former is certainly the best map of the Northern Islands yet issued to the public. The latter, which is founded upon the well-known map of the Duke of Sutherland, is most interesting from the fact that it embodies the results of the extended geological researches of the author in the disputed Durness and Assynt region. It is published separately, and is accompanied by a separate pamphlet, explanatory of the author's views.

In his descriptions of minerals and mineral localities, Professor Heddle is most patient and painstaking; but his accounts of the scenery and geognosy of the different areas are most attractive to the geological reader. He hurries us onward from point to point and scene to scene, hardly allowing us time to take breath. His style is often a little high-pitched perhaps, but never flat or uninteresting. Through all we catch the enthusiasm of the lover of nature, the flow of joyous animal spirits, the sweet breath of fresh air, and the exhilaration of the mountain breeze. The mass of the work is of course interesting only to the mineralogical student, to whom the book in its completed form will become an absolute necessity. But much of it is interesting not only to British geologists in general, but to all those who love nature and nature's interpreters: and we trust that the author will find time and opportunity to complete a work so worthily begun.

# REPORTS AND PROCEEDINGS.

## GEOLOGICAL SOCIETY OF LONDON.

I.—June 7, 1882.—J. W. Hulke, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1.—The President read the following note, forwarded by Don Manuel F. de Castro, Director of the Geological Survey of Spain:—"On the Discovery of Triassic Fossils in the Sierra de Gador, Province of Almeria, Spain."

"The metalliferous limestone of the Sierra de Gador, owing to no fossil remains having been found prior to this occasion, has been a perfect puzzle to all geologists for the last fifty years.

"MM. Maestre, Amar de la Torre, Pernolet, Ansted, and Cooke considered these limestones to belong to the Transition series, the former taking it as a representative of the Mountain Limestones of other parts of Europe. M. Prado hinted that they might be Devonian; whilst M. Willkomm, in the geological map published to accompany his botanical researches in Spain, considered them Silurian. Lately, MM. Botella and Vilanova, in their respective maps, have marked them as belonging to the Permian series; whilst M. de Verneuil, coming nearer to the truth, took the whole of the lime-ones to the south of Granada and the Sierra de Gador as Triassic, ough in doubt ('Trias incertain').

"Under these circumstances, I was commissioned by the Director f the Geological Survey of Spain to investigate the S.W. portion of e Province of Almeria, which comprises the Sierra de Gador. In ebruary last I had the good fortune of discovering abundant fossil emains in different parts of the Sierra de Gador, which perfectly fix e age of the metalliferous limestones of this part of Spain.

"The whole series of rocks forming this *sierra*, resting on the ica-schists and slates of the Sierra Nevada, is a succession of black, hite, and purple talcose schists at the base, which alternate with ome beds of yellowish and porous limestone, and which pass hrough a considerable thickness of grey limestones and slates, and recisely where the fossils have been found, to the metalliferous imestone of Sierra de Gador, which appears to form the top of this nteresting formation.

"The fossils found belong to the following genera:—*Myophoria* *M. lævigata* and *M. Goldfussi*), *Hinnites*, *Monotis*, *Avicula* (*A. Bronni*), *yacites*, *Rissoa*, and many others difficult to determine.

"The places where the fossils have been found are the following: n the southern slopes of the Sierra de Gador, in the Rambla del añuelo; midway on the road from Felix to Marchal; and in the lace named La Solana del Fondon, to the left of the River Andarax, ollowing the track between the mine Sebastopol and the town of l Fondon. JOAQUIN GONZALO Y XAVIER."

2. "The Girvan Succession.—Part I. Stratigraphical." By harles Lapworth, Esq., F.G.S., Professor of Geology in the Mason cience College, Birmingham.

The Lower Palæozoic rocks of the neighbourhood of Girvan, in he south of Ayrshire, have long been famous for the remarkable ariety of their petrological features, and for the abundance and eauty of their organic remains; but the strata are so intermingled nd confused by faults, folds, and inversions, that it has hitherto een found impossible to give a satisfactory account of the geological tructure of the region.

The most remarkable formation in this Girvan area is a massive oulder-conglomerate, several hundreds of feet in thickness, which rms the high ground of Benan Hill, and ranges throughout the istrict from end to end. Employing this formation as a definite orizon of reference, the author showed, by numerous plans and ections, that it was possible for the geologist to work out the natural rder of the strata, both above and below this horizon, and to construct a complete stratigraphical and palæontological scheme of e entire Girvan succession. This succession is composed of the ollowing members, arranged in descending order:—

### (I.) UPPER GIRVAN ROCKS.

D.) DAILLY SERIES (1500 to 2000 feet), including the

(3) *Straiton Group*, consisting of grey flags, shales, and grits, with *Beyrichia Klædeni*, *Cardiola*, etc.

(2) ***Bargany Group***, of pale flagstones, shales, and mudstones, with ***Retiolites Geinitzianus***, *Cyrtograptus Grayi*, etc.

(1) *Penkill Group*, of purple mudstones, grey flags, and greywackes, with *Crossopodia*, *Protovirgularia*, etc.

(C.) NEWLANDS SERIES (1000 to 1500 feet), embracing the

(3) ***Camregan Group***, etc., of yellow thick-bedded grits and dark shales, with a band of calcareous rock; abounding in ***Pentamerus oblongus***, ***Atrypa reticularis***, ***Rastrites maximus***, and ***Monograptus Sedgwickii***.

(2) ***Saugh-Hill Group***, composed of alternations of coarse pebbly grit and zones of grey and black shales, with a coarse conglomerate at the base. Its commonest fossils are ***Stricklandinia lens***, ***Pentamerus oblongus***, ***Favosites gothlandicus***, ***Monograptus leptotheca***, etc.

(1) ***Mulloch-Hill Group***, formed of shelly sandstones underlain by a coarse boulder-conglomerate, and containing hosts of Brachiopoda, etc., chiefly ***Meristella angustifrons***, ***Atrypa hemisphærica***, ***Nidulites favus***, etc.

## LOWER GIRVAN ROCKS.

(B.) ARDMILLAN SERIES (1800 to 2000 feet), embracing the

(4) *Drummuck Group* of soft grey mudstones, etc., with ***Trinucleus seticornis***, ***Ampyx***, ***Staurocephalus***, ***Dicellograptus***, etc.

(3) ***Barren or Shalloch Flagstones.***—A great thickness of alternations of grey or green flagstones and shales, generally destitute of fossils.

(2) *Whitehouse Group.*—Purple and green shales and mudstones, striped flagstones and calcareous beds, with ***Dionide***, ***Dindymene***, ***Æglina***, ***Agnostus***, ***Dictyonema***, ***Dicellograptus***, and ***Pleurograptus***.

(1) ***The Ardwell Group*** of dark Graptolitic flagstones and shales, with occasional fossiliferous seams affording examples of ***Dicranograptus***, ***Leptograptus***, and *Climacograptus*, etc.

(A.) BARR SERIES (800 to 1000 feet), composed of the

(4) ***Balclatchie Beds.***—Highly fossiliferous pebbly grits and nodular shales, with *Lingula Ramsayi*, *L. canadensis*, *Siphonotreta micula*, *Remopleurides*, *Glossograptus*, etc.

(3) *Benan (or Green) Conglomerate.*—Massive boulder-beds of great thickness, unfossiliferous.

(2) *Stinchar (or Craighead) Limestone Group*, composed of compact limestones, nodular and calcareous flagstones and shales, with *Maclurea Logani*, *Ophileta*, *Orthis confinis*, *Tetradium*, *Didymograptus*, *Clathrograptus*, etc.

(1) *Kirkland (or Purple) Conglomerate.*—Coarse boulder-beds and sandstones, generally of a purple colour.

It was shown that the highest beds of this succession are faulted against strata of Carboniferous age. The discussion of the relationship of its lowest beds to the igneous and metamorphic rocks of Ballantrae was deferred to a future paper. The author pointed out how perfectly this reading of the succession explained the anomalies hitherto supposed to obtain among the fossils of the Girvan region. When the organic remains collected from these strata by previous investigators (notably the magnificent Gray collection) are referred to their natural horizons in this stratigraphical succession, it is found that each of the great petrological divisions of the Girvan series has a collective fauna peculiarly its own, and that the general zoological gradation is identical with that of the acknowledged sequence in the typical Lower Palæozoic areas in Wales and the West of England.

The Lower Girvan rocks are clearly of Ordovician age; while the Upper Girvan rocks as distinctly appertain to the Silurian. The *Barr Series* corresponds to part of the Llandeilo-Bala of Wales; and the *Ardmillan Series* is of Caradoc-Bala age. The *Newlands Series* answers to the Llandovery formation of Murchison, containing similar fossils and corresponding local breaks in the succession. The *Purple Shales* of Penhill correspond in systematic position, petrological features, and fossils with the Tarannon; and the *Straiton Beds* represent the lower division of the Wenlock.

The development of the palæontological features of the several zones of life in this succession, and the demonstration of their correspondence with the zones already recognized in the synchronous Lower Palæozoic strata of Moffat, the Lake-District, Scandinavia, and elsewhere, were reserved by the author for a second part of this memoir.

3. "Notes on the *Annelida tubicola* of the Wenlock Shales, from the Washings of Mr. Geo. Maw, F.G.S." By Geo. R. Vine, Esq. Communicated by Prof. P. Martin Duncan, M.B., F.R.S., V.P.G.S.

The author commenced with a sketch of the bibliography of the subject and of the known Silurian genera of tubicolar Annelids. This was followed by a description of the following genera and their contained species:—*Cornulites, Conchicolites, Ortonia, Spirorbis.* Of the last there is one species (*S. minutus*) from the Buildwas Shale; this differs only in the slightest degree from *S. arkonensis*, described by Prof. Nicholson from the American Devonians. This new genus, *Arenatubulites*, is in many respects a peculiar and interesting form, having the tube composed of minute grains of sand, like *Sabellaria* and *Terebella*. The author describes two species, *A. elongata* and *A. amplexus*; they occur in the Pickwood beds. A description follows of the genus *Tentaculites*, which the author referred to the Tubicolar Annelids, and several species of it were described.

4. "Description of Part of the Femur of *Nototherium Mitchelli*." By Prof. Owen, C.B., F.R.S., F.G.S., etc.

The specimen described consisted of the distal portion, probably about one-half, of a femur obtained from Darling Downs, Queensland, and received by the author from Dr. George Bennett. Its principal differences from *Diprotodon* are that it has no depression above the outer condyle, but in its place a rough longitudinal rising for the attachment of the same or of a homologous muscle; and the hinder surface of the outer condyle is transversely convex. The relative width of the post-condylar fossa resembles that in *Phascolomys*; and a further resemblance to the Wombats consists in the more equal prominence of the lateral boundaries of the rotular surface than in *Diprotodon* and *Macropus*. The bone differs from the corresponding part in the Wombats by several subordinate characters, and the animal to which it belonged would seem to have been intermediate between *Phascolomys* and *Macropus*. From the size and characters of the bone the author referred it to *Nototherium Mitchelli*; its breadth across the condyles is 5¾ in.

5. "On *Helicopora latispiralis*, a new spiral Fenestellid from the Upper Silurian beds of Ohio, U.S." By E. W. Claypole, Esq., B.A., B.Sc. (Lond.), F.G.S.

The author referred to the genus *Archimedes*, recognized by Lesueur, D. D. Owen, and James Hall, as a spiral form of Fenestellid, the remains of several species of which occur in Lower Carboniferous Limestone rocks in the United States. In *Archimedes* there is always a strong central shaft. The species here described by the author under the name of *Helicopora latispiralis* occurs in the Upper beds of the Niagara group of the Upper Silurian at Cedarville, Ohio; and the new genus is distinguished from *Archimedes* by the absence of the solid stony axis above mentioned. Its character as given by the author is as follows:—"Polyzoary expanded, fenestrate, and spiral, formed of slender, bifurcating branches poriferous on one face, connected by non-poriferous bars forming an open network; cells arranged in two rows along the branches, one row on each side of a median keel. Axis very thin, or consisting only of the thickened central border of the spiral polyzoary." The species described grows to as much as eight inches in diameter. The author has seen a second species of the genus.

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II.—June 21, 1882.—J. W. Hulke, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On *Thecospondylus Horneri*, a new Dinosaur from the Hastings Sand, indicated by the Sacrum and the Neural Canal of the Sacral Region." By Prof. H. G. Seeley, F.R.S., F.G.S.

The author described a mould of the neural canal of the sacral region of a Dinosaur, obtained by Dr. A. C. Horner, of Tunbridge, from a quarry in the Hastings Sand at Southborough. The specimen is about 2 feet long, slightly imperfect at both ends, but showing indications of five complete vertebræ, with traces of others at the two extremities, making at least seven vertebræ in all. The general form of the neural chamber is compressed from side to side, and dilated from below upwards, especially in the region of the second, third, and fourth vertebræ, its depth over the third foramen being nearly 3½ inches. Indications of bone preserved on the surface seem to show that the neural canal was inclosed in a mere bony film. The indications of transverse processes show that they were directed forward in front, outward in the middle, and backward behind. The first process on the right side, which is preserved, expands somewhat conically outwards and forwards, and terminates in a large flattened facet for the ilium. For the animal indicated by this specimen the author proposed to found a new genus, *Thecospondylus*, and named the species *T. Horneri*.

2. "On the Dorsal Region of the Vertebral Column of a new Dinosaur, indicating a new genus, *Sphenospondylus*, from the Wealden of Brook, in the Isle of Wight, preserved in the Woodwardian Museum of the University of Cambridge." By Prof. H. G. Seeley, F.R.S., F.G.S.

In this paper the author described a series of six vertebræ, remarkable for the great lateral compression of the centrum, which is so narrowed inferiorly as to terminate in a sharp longitudinal ridge. The centra average about 3½ inches in length. The neural arches are depressed; the transverse processes are at first directed backward, but soon become directed outward, retaining their upward direction; the facet for the head of the rib is at first large, placed at the base of the transverse process and bounded behind by a sharp ridge which runs to the hinder margin of the neural arch; but afterwards the rib-head rises higher, so as to be chiefly above the zygapophysial facets, and then it becomes smaller, the ridge behind it disappears more or less, and the transverse process becomes vertically compressed and thin. The author referred to other vertebræ showing similar characters contained in the Fox Collection in the British Museum, but stated he had seen neither cervical nor caudal vertebra of this type. The animal indicated by these remains was regarded by the author as constituting a new genus most nearly allied to *Iguanodon*, for which he proposed the name of *Sphenospondylus*; but he abstained from giving the type a specific name "in view of the likelihood of these vertebræ pertaining to the *Iguanodon Seelyi*."

3. "On Organic Remains from the Upper Permian Strata of Kargalinsk in Eastern Russia." By W. H. Twelvetrees, Esq., F.G.S.

In this paper the author described the Kargalinsk steppe, north of Orenburg, as consisting of a grassy, treeless, undulating steppe, with sluggish, winding streams, in the banks of which, and in ravines, the exposures of subsoil show only red marl or sandstone devoid of fossils. Mine-borings and shafts go down through red, yellow, and grey sandstones and red and white marls, which are fossiliferous wherever the beds of copper-ore exist. On the eastern border of the steppe there are two protrusions of limestone, with *Terebratula elongata*, *Loxonema*, etc., on outcrops running nearly N.W. and S.E., which throw off the cupriferous sands east and west. The western of these outcrops in its southern continuation near Sakmarsk is charged with Permian fossils, including the above; the same limestone, regarded by the author as belonging to the Zechstein, crops up in other places and apparently underlies the whole basin of the steppe, the upper sandstones resting conformably upon it. From the latter the author gave the following list of fossils:—*Cardiopteris Kutorgæ* (= *Aroides crassispatha*), *Walchia biarmica* and *piniformis*, *Lepidodendron*, *Schizodendron tuberculatum*, *Anomorrhœa Fischeri*, *Caulopteris ?*, *Calamites infractus*, *Suckowi*, *gigas*, and *leioderma*, *Unio umbonatus*, *Platyops Richardi* (a Labyrinthodont), *Rhopalodon Wangenhäuseri*, *Cliorhizodon orenburgensis*, *Deuterosaurus*, and various Labyrinthodont and Reptilian remains. Upon these the author remarked that the list of plants has a Palæozoic aspect, while the Reptilian remains seem to be more of a Secondary character. After consideration of all the facts, the author came to the conclusion that possibly some of the beds in the central part of what is known as the Permian basin may be passage-beds between the Permian and Trias, but that the Kargalinsk series includes the uppermost beds of the Permian.

4. "The Rhætics of Nottinghamshire." By E. Wilson, Esq., F.G.S.

During the last few years several sections of the Rhætic beds, in addition to those already known near Gainsborough and Newark, have been exposed in making railway-cuttings. These were described by the author. The beds usually assigned to the Rhætic consist of Lower Rhætic—greyish or greenish marls; Middle or *Avicula-contorta* series; and Upper Rhætic (white Lias), a series of variable shales and light-coloured limestones. The author pointed out that in the Nottinghamshire district there is always a clear line of division, and sometimes indications of erosion between the *Avicula-contorta* series and the so-called Lower Rhætic beds, while the latter graduate down uninterruptedly into the Upper Keuper Marls. Further, they are practically unfossiliferous, while in the other series there is evidence of marine life and the remains of a fauna ranging upwards into the Lias. Hence the author proposed to class these Lower Rhætics with the Trias, and regard the Rhætic series as commencing with the base of the *Avicula-contorta* group.

5. "On the Silurian and Cambrian Strata of the Baltic provinces of Russia, as compared with those of Scandinavia and the British Islands." By Dr. F. Schmidt. Communicated by Dr. H. Woodward, F.R.S., F.G.S.

The Cambrian and Silurian strata in question are found stretching over an area 400 miles long by 80 miles wide. The country occupied by these strata is a nearly uniform plain covered by glacial deposits, but sections are presented by the sea-cliffs, which are from 90 to 150 feet high. The strata consist mainly of marls and limestones, arenaceous deposits being rare, and they form a continuous series from the base of the Cambrian to the top of the Silurian, the whole of these strata being in conformable succession and unconformably overlain by the Devonian. Although the representative of the Cambrian or Primordial Silurian contains neither *Paradoxides* nor *Olenus*, nor, indeed, any Trilobites whatever, but only Lingulidæ and Graptolites, yet its stratigraphical position leaves no doubt as to its age. The Lower Silurian or Ordovician is the richest of the divisions, the strata of this age forming a perfectly continuous series. The author divides these beds into the stages B, C, D, E, and F, several of which are divisible into substages. Of the stage B the lowest bed, 1 to 10 feet thick, consists of the Glauconite-bands containing the casts of Foraminifera described by Ehrenberg, which correspond to the *Ceratopyge* stage of the Scandinavian geologists. Above this, and closely connected with it, is the Glauconite-limestone, from 12 to 40 feet thick. Next comes the famous *Orthis*-limestone, a thin bed with a very interesting fauna, corresponding to that of the *Phyllograptus*-schists. The author's beds C, D, E, and F can be paralleled with the strata of Scandinavia, but have no exact representatives in the British Islands. The stage E appears to represent the Bala of England or the Trenton of North America. Although there is no stratigraphical break, there is a marked palæontological division between the Upper and the Lower Silurian, there being no strata of intermediate age represented. The Upper Silurian is divided by the author into the stages G, H, I, K, which can be exactly correlated with the strata of Scandinavia. The stages G, H do not appear to have precise representatives in the British Islands, but I is undoubtedly equivalent to the Wenlock, and K to the Ludlow. In the Baltic provinces there are no representatives of the passage-beds and Lower Devonian, but the Silurian strata are unconformably covered by the Old Red Sandstone with *Coccosteus*, *Asterolepis*, *Bothriolepis*, *Homosteus*, and *Heterosteus*, there being a marked overlap between the two series. The author argues in favour of considering the Cambrian, Ordovician, and Silurian as forming, in the Baltic provinces, one "system." The author is able to construct a section connecting the Silurians of Russia and Scandinavia, and passing through the islands of Góthland and Oesel. The paper is accompanied with a map and a tabulated list of fossils found at the several horizons which have been distinguished by the author. He points out which of these species are found ranging into other areas, and proposes eventually to publish figures and descriptions of the characteristic Russian forms. The first part of the author's palæontological work has just appeared in the shape of a memoir describing 60 species of Trilobites of the genera *Phacops*, *Cheirurus*, and *Encrinurus*. The total number of species of the Trilobites is about 150, of which only about 15 occur in the Upper Silurian.

6. "On Chilostomatous Bryozoa from Bairnsdale (Gippsland)." By A. W. Waters, Esq., F.G.S.

This paper continues the author's work on South Australian Bryozoa, already communicated to the Society. It describes a collection made by Mr. J. R. Y. Goldstein, containing 40 forms, of which 12 were not previously known to have existed in Australia. Several species, however, known in other places as incrusting, here occur in the *Eschara* habit, and altogether the number of incrusting species from this locality is small. The author calls attention to the frequency with which the Australian Bryozoa exhibit different modes of growth, showing the importance of preferring for classification zoœcial to zoarial characters. The three localities in Australia have furnished 126 species of Chilostomata, of which 51 are known living and 41 fossil; 14 are considered identical with European Miocene species, 17 with Pliocene, and 4 are thought to be identical with Cretaceous species. The author gives a detailed description of the various species in his Bairnsdale collection.

7. "The Silurian Species of *Glauconome*, and a suggested Classification of the Palæozoic Polyzoa." By G. W. Shrubsole, Esq., F.G.S., and G. R. Vine, Esq.

The author discussed the history of our knowledge of the genus *Glauconome*, and especially of the Silurian species. They then characterized the genus, to which they refer only the Bala species formerly regarded as identical with *G. disticha*, Goldf., but which they describe as *G. Sedgwickii*, Shrubs. *Glauconome disticha*, Goldf., from the Wenlock of Dudley, is taken as the type of a new genus, *Arcanopora*.

The authors then remarked upon the characters on which the classification of the Polyzoa is founded, drawn from the study of the recent forms, and stated that throughout the Cainozoic and Mesozoic series no Polyzoa are known which cannot be referred to the recognized groups. Many Palæozoic forms are in a different case. The orifices seen on the surface are not, in many instances, the mouths of the cells, but those of what the authors call *vestibules* beneath which the true cell-mouth is concealed. For these types they propose to found a new suborder under the name of CRYPTOSTOMATA, and characterized by having the zooecia subtubular, or, in section, slightly angular, and the orifice surrounded by a vestibule or otherwise concealed. The families referred to this group are the Ceramoporidæ, Ptilodictyidæ, and Arcanoporidæ.

8. "On the Cause of the Depression and Re-elevation of the land during the Glacial Period." By T. F. Jamieson, Esq., F.G.S.

The author commenced by noticing the theory advanced by Adhémar and Croll, according to which the submergence was due to the effect of a polar ice-cap causing a displacement of the earth's centre of gravity and thereby drawing the ocean towards the ice-covered pole, and proceeded to show that this theory is opposed to the geological evidence, according to which the amount of submergence has been unequal in adjacent areas and along the same parallels of latitude, showing that the movement has been in the land and not in the sea. The facts of submergence also prove that no such cap of ice could have existed at the time in the northern regions. Sundry other objections were also pointed out. The author then went on to state his own hypothesis, which is to the effect that the depression of the land was caused by the weight of ice laid upon it, and the re-elevation by the disappearance of the ice. The amount of depression would depend partly on the weight of ice and partly on the elasticity or yielding nature of the ground beneath it. He then proceeded to consider what was the weight of ice that probably existed, and referred to the elastic and flexible nature of the earth's crust, as evinced by earthquakes, etc.

He further considered the relation of time to pressure, and touched upon the probable rate of subsidence, which he supposes to have been very slow and gradual. The recovery of level, he thinks, would be very gradual, and probably, in most cases, not complete.

He next proceeded to show how his hypothesis is borne out by an appeal to geological evidence in various countries, taking England, Ireland, North America, and Greenland as examples. He further pointed out its application to the facts connected with the loess beds, fjord latitudes, and lake-basins, and concluded with some observations on the remarkable connexion between glaciation and submergence in all countries.

## CORRESPONDENCE.

### THE MOON'S ACTION ON THE EARTH.

SIR,—I dare say your readers will have been much interested lately by Professor Ball's new speculations regarding the moon's action on the earth, and especially in the creation of geological changes on its surface by it. His theory purposes to establish gigantic tides in the far-off history of the Earth, upheaved by a *closer approximation* of the moon, and creating thereby a tremendous force of current to act as a powerful denuding agent. I am strongly inclined to think that some fallacy lurks beneath this ingenious theory in a geological point of view. In the first place, the moon's action creates no currents in the open sea, the open tide being merely a wave (or elevation) of translation. The water in the wave does not follow the moon at all, but as soon as the moon has passed that spot, falls down again. 2nd. The tidal flows and ebbs in inclosed channels and seas do not denude the bounding lands into valleys and gorges, but level it flat, into sand banks and mud banks. 3rd. The awful rise and fall of tides of 648 feet up and down should throw further doubt upon the theory, as such could only take place in the open ocean far away from land. It would be quite impossible in our narrow seas, where the water would not be deep enough for it. 4th. A wave of water cannot be conceived to travel over land like a gale or hurricane, as it would collapse at once when brought into shallows of its own depth from the open sea. 5th. As these waves of translation must have corresponding troughs of water to draw upon, where could they get them, except in the open oceans, certainly not in coast seas? 6th. Therefore the disruptive and denuding agency expected from such tides on the dry land of continents, I beg to suggest would be illusory, and impossible of achievement. The student of Geology will do better to adhere to the principles of Geology taught by Sir C. Lyell, than put faith in Professor Ball's theory of tidal deluges repeated every day and tearing up diurnally the surface of the globe.

FESTINA LENTE.

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## THE BRIDLINGTON CRAG.

SIR,—As my paper on the Bridlington and Dimlington shell-beds was meant to be descriptive, I did not think it necessary to lay particular stress on the evidence which caused me to doubt Mr. S. V. Wood's assertion that "the Bridlington shells unquestionably lived where they occur," and I contented myself with showing that "the most perfect preservation" of the shells, on which it seemed to me that Mr. Wood had mainly relied, was not certain evidence; and I thought the general account given of the beds would have proved the rest. Since, however, Mr. Wood has drawn attention to the matter, it will perhaps be as well to group the facts which caused me to differ from him.

My reasons for thinking that the shelly patches in the Basement Boulder-clay are not in place, but have been transported, are briefly as follows:—1. Neither at Bridlington nor at Dimlington do they show any signs of extension or regularity; at both places they exhibit the same mixture of remnants; and the patches—composed of many kinds of sand, gravel, silt and clay, some with shells of one kind, some of another, many with none—all, so far as I have seen, occur at random in the clay, like boulders. 2. Most of the patches are made up of material which I do not think could have been obtained on this coast at that time. Coarse grains of greenish quartz form much of the sand, whilst the fine blue clays have, I think, been made up, in great part, of the waste of soft Neocomian beds. There are indeed some masses of drift-gravel and chalk wash at and near the top of the Boulder-clay, which seem to have been formed on the spot; but these contain no shells. 3. Fragments of Secondary deposits occur in the clay in the same way as these shelly patches. See Prof. Phillips's description of a large mass of Lias with fossils (which did not live where they occur) on the beach at Bridlington; (Geol. of Yorkshire, 3rd ed. p. 85); Mr. Mortimer's, of a mass of chalk with lines of black flint, at Easington (Proc. Yorkshire Geol. Soc. 1881, p. 375); and my own, of Neocomians at Flambro (Proc. Yorks. Geol. Soc. 1880, p. 245), and at Dimlington (Geol. Mag. Dec. 1881, p. 541). 4. The whole aspect of the clay shows that the drift has *not* been *from* the land. The proportion of chalk in it is not great, the flints are nearly always black or red, and not grey like those in the Yorkshire Chalk, strange igneous rocks are plentiful, and Lias and Neocomian remains are relatively far too abundant to have been carried over from the opposite side of the Wolds.

The evidence is also against the view that the confusion in the beds may be attribnted to the passage of later ice; for though there are signs that this has had its local effect, yet as the Basement Clay retains its peculiar features where beds of sand, gravel, or laminated clay come between it and the overlying Boulder-clay, its character cannot have been greatly altered.

The sands and gravels connected with the *Purple* Clay, to which Mr. Wood at first referred these shells, have evidently in most cases been deposited where they now lie, and formed from the same materials as the clay. But if Mr. Wood has not seen the shelly beds I described, and has had his impression that they are in place confirmed by my paper, I fear my descriptions must be misleading, and I beg leave now to correct them on this point.

It must always be remembered that at Dimlington there is a great space between the Shelly Boulder-clay and the Chalk which is as yet entirely unaccounted for, and it is very probable that traces of undisturbed shell-beds may some time be found lower down in the section.

G. W. Lamplugh.

Bridlington Quay.

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## HIGH-LEVEL DRIFTS IN NORTH AMERICA.

Sir,—In answer to Mr. Lesley's important letter on high-level drifts, I would beg to state that those I discovered on Minera mountain, North Wales, contained marine shells up to about 1280 feet above the present sea-level, while shells had previously been found on Moel Tryfan up to 1370 feet. I have not yet heard of shell-bearing sand and gravel in North America at a higher level than 700 feet. Is this their extreme altitude?

D. Mackintosh.

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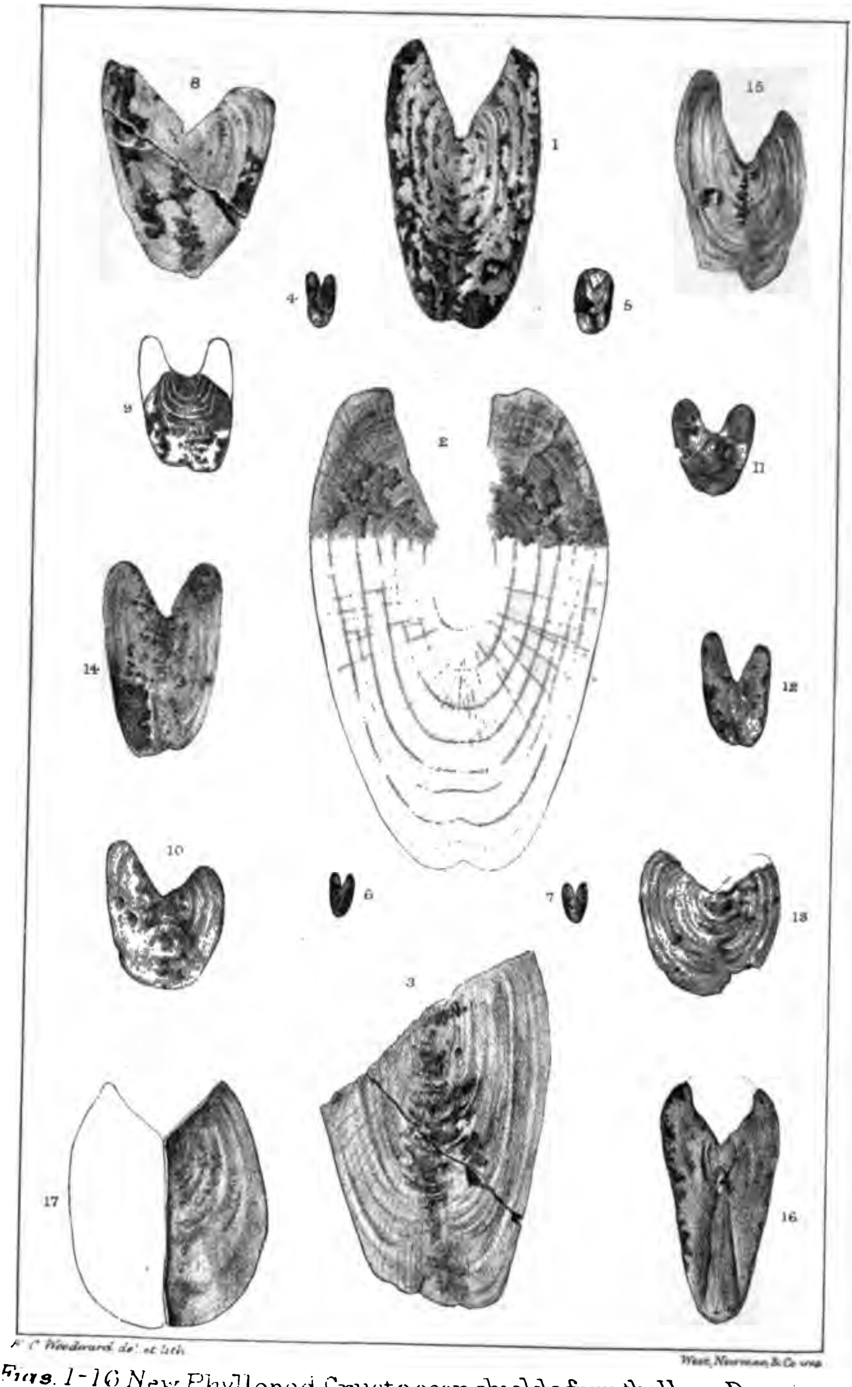
Eratum.—On page 320, in the fourth column, the first three lines should not read as printed with the brace, but as follows:—

Overlying Zone of *Ammonites planorbis*.

$\left\{\begin{array}{l}\text{Kössener Schichten and Dachstein Series.}\\ \text{‘Hauptdolomit’ of Tyrol, and ‘Plattenkalk.’}\end{array}\right.$



F. C. Woodward del. et lith.
West, Newman & Co imp.

Figs. 1-16, New Phyllopod Crustacean shields, from the Upper Devonian, Eifel: & Fig. 17 from the U. Sil les.

THE
# GEOLOGICAL MAGAZINE.
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No. IX.—SEPTEMBER, 1882.

## ORIGINAL ARTICLES.

## I.—On a Series of Phyllopod Crustacean Shields from the Upper Devonian of the Eifel; and on one from the Wenlock Shale of S. Wales.

By Henry Woodward, LL.D., F.R.S., F.G.S.,
of the British Museum.

(PLATE IX.)

HAVING in the autumn of 1878 arranged to make a geological excursion to the Eifel, with my friend Mr. John Edward Lee, F.S.A., F.G.S., of Torquay, we were so fortunate, when near Gerolstein, to meet Professor Dr. Ferdinand Roemer, of the University of Breslau, Silesia, who has made the Eifel region his special study, and who cordially joined our party, giving us the benefit of his great knowledge of this most interesting geological region.[1]

And here let me say, that to any one interested in Devonian Geology and desirous to collect fossils, for themselves, or to study the volcanic phenomena of the district, I cannot conceive a more delightful and primitive region for a fortnight's hammering. Mr. Lee was particularly anxious to direct our attention to the Upper Devonian beds of Büdesheim (between Gerolstein and Prüm), which he had carefully studied on a former visit in 1875.[2] Besides abundance of small *Goniatites* and *Orthoceratites*, we found by splitting open the shale that every lamina had numbers of bilobed impressions of some fossil organism on its surface, each being coated with a black pergamous layer, which, owing to the wetness of the shale, from springs, was only too easily removed, and when the specimens were dried it had a propensity to curl up or split and flake off, leaving only an impression behind.

These markings, from their blackness and rounded contour, are called by the natives "tinter-flecken" (ink-spots). My first impression, on examining them, was that they were *opercula* most likely of *Goniatites*, so abundant in these Büdesheim beds, but after visiting the locality and making a more careful examination of the fossils *in situ*, I was convinced they could not be referred to the Cephalopoda, and that their true nature was that of Phyllopod Crustacean shields.

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[1] See das Rheinische Uebergangsgebirge. eine palæontologisch-geognostische Darstellung, von Carl Ferdinand Roemer, Phil. Doc. Hannover, 1844, 6 plates, 4to., and numerous other papers on the fossils of this region by the same author.

[2] See paper by Mr. J. E. Lee, on the Discovery of Upper Devonian fossils in the shales of Saltern Cove, Torbay, identical with those of Büdesheim (Geol. Mag. 1877, p. 100, Pl. V.).

Had it been possible to have described these fossil organisms upon the spot, and make careful drawings of them at the time, I do not doubt but that I should have been enabled to do them fuller justice than I can now after an interval of four years; but other claims upon my time have prevented my undertaking their description earlier.

The specimens selected and figured on Plate IX. (which, *with one exception*, are all from Büdesheim) seem to resolve themselves into three genera and six species.

Fifteen of the Eifel specimens I have referred to one genus, which I propose to name *Cardiocaris;* the sixteenth I propose to call *Pholadocaris;* the seventeenth specimen was obtained by Mr. J. E. Lee at Pencerrig in Wales, and I have referred it to the genus *Aptychopsis.*

(I had at first wished to place the first fifteen of these forms in the genus *Aspidocaris*, but I found that this name was already adopted by the late lamented Prof. Reuss, of Vienna, for a series of Phyllopod shields from the Alpine Trias of Raibl, Austria.[1] These specimens agree so *very closely* with *Discinocaris*,[2] a genus proposed by me for certain Phyllopod shields from the Moffat Shales, Dumfriesshire, that I am unwilling to complicate matters by adding these Eifel specimens to Reuss's Triassic genus, as a later examination may induce me to refer Reuss's *Aspidocaris* to the genus *Discinocaris*, when the former would sink into a synonym.)

## I. *Cardiocaris*,[3] gen. nov.

### 1. *Cardiocaris Rœmeri*, mihi, sp. nov. Pl. IX. Figs. 1–7.

In dedicating this species to my esteemed friend and fellow-worker, Prof. Dr. Ferdinand Roemer, of Breslau, I feel that I am adding to the value of the specimens which will bear his honoured name, and that Mr. Lee's collection will be the richer for this souvenir of a friendship with this eminent geologist which he has shared for some years with myself.

To this species I have referred three of the largest, and four of the smallest, of these phyllopod shields; all of those having an elliptical outline and in which the anterior angles, formed with the cervical furrow or groove, are more or less acute.

The best preserved of these is depicted in Fig. 1, which measures 35 millimètres in greatest length (and probably measured 45 mm. before the loss of its anterior or cephalic portion), and 20 mm. in greatest breadth. The dorsal suture, if present, seems extremely obscure; the concentric striæ are pretty numerous, and are marked at intervals by a line of greater strength than the rest. There are also numerous delicate radiating striæ which take their rise just behind the base of the V-shaped cervical furrow and spread out fan-wise towards the posterior border, which is slightly emarginated behind.

Fig. 2 is only a fragment of a much larger shield, which must

[1] Sitz. d. K. Akad. d. Wissensch. I. Abth. Februar-Heft, Jahrg. 1867.

[2] Quart. Journ. Geol. Soc. 1866 (vol. xxii. p. 503, pl. xxv. figs. 4, 5, and 7.)

[3] From καρδία, a heart; and καρίς, a shrimp.

(if entire) have measured fully 65 mm. in length and 40 mm. in breadth. We have only the anterior portion of this shield, but it shows, that in such aged specimens, the fine radiating striæ extended forwards as well as towards the posterior border.

Fig. 3 supplies exactly the portion of a large shield which is wanting in Fig. 1. The two series of striæ upon this specimen are beautifully preserved as impressions on the shale, although the black layer is absent. The concentric striæ bend slightly upwards on the posterior dorsal line. This specimen, when entire, must have measured 50 mm. in length and 30 mm. in greatest breadth.

Figs. 4, 5, 6, and 7 present in miniature all the characters of Fig. 1, and might be disposed of at once, as young examples of *C. Rœmeri*, but Fig. 5 deserves special notice.

In this little specimen the V-shaped cephalic portion, so frequently absent in the shields of these phyllopods, is here preserved *in situ*.

The question very naturally arises, why is the cephalic portion nearly always separated from the rest of the carapace? If we carefully examine the anatomy of specimens of the existing *Apus*, *Lepidurus*, or *Nebalia*, we shall find the answer very readily. The fact is, the muscles of the natatory antennæ, the maxillæ, and maxillipeds in these Phyllopod Crustaceans, all have their attachment to the anterior portion of the cephalic shield, and in the process of decomposition, after death, the carapace appears usually to have separated along the cephalic suture; the anterior part, with the appendages, being entombed in one spot, and the expanded posterior shield-shaped portion floated to another.[1]

When occasionally found together, as in *Ceratiocaris papilio*, Salter, from the Upper Silurian of Lesmahagow, Lanarkshire (see Annals and Mag. Nat. Hist., March, 1860, p. 154), the body is often so twisted about in relation to the shield-shaped carapace, that the anterior end has more than once been described as the posterior, and *vice versa*. I pointed this out also in reference to *Dithyrocaris tricornis* of Scouler (see GEOL. MAG. 1873, Vol. X. Pl. XVI. p. 482).

### 2. *Cardiocaris veneris*, mihi, sp. nov. Plate IX. Figs. 8–12.

Under this specific designation, I have grouped together five carapaces, in which the cervical suture is less acute than in the preceding species, and the anterior angles of the carapace are rounded or obtuse, giving to these shields the traditional outline of an heraldic heart, or the form which is supposed to represent that organ on valentines. It is very difficult in this, as in the preceding species, to determine the presence of a dorsal suture dividing the shield into two equal halves. The surface of the carapace, when closely examined, reveals the same concentric striæ, but not the fine radiating lines seen on the preceding species. The relative proportions of breadth to length differ greatly in *C.*

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[1] The carapace, which forms the subject of Fig. 10, on our Plate, has the impression of a *Spirorbis* having been attached to its surface after death. Others also appear to bear scars of organisms having fixed upon them; probably "spat" of Ostreæ or other small mollusks.

*veneris* when compared with *C. Rœmeri*. For whilst the latter is nearly twice as long as it is wide, the former is nearly as wide as it is long. In *C. Rœmeri* the greatest breadth of the shield is measured across the angle at the base of the V-shaped cervical suture; in *C. veneris* the greatest breadth is in front, measured across the summit of the V-shaped suture.

Dimensions of three specimens of *C. veneris*:—

| | | | | |
|---|---|---|---|---|
| Fig. 8. | Breadth in front | 23 mm., | length | 30 mm. |
| Fig. 11. | „ „ | 10 „ | „ | 15 „ |
| Fig. 10. | „ „ | 15 „ | „ | 20 „ |

### 3. *Cardiocaris lata*, mihi, sp. nov. Plate IX. Fig. 13.

I have ventured to separate this from the preceding species on account of its broader and rounder contour, and the more obtuse angle of the cervical suture. There is no trace whatever of any dorsal suture, the concentric striæ of the carapace pass completely round the shield in unbroken lines. Breadth of carapace 18 mm., length from anterior border to back of shield 20 mm., length from angle of cervical suture to back of shield 14 mm. This form approaches most nearly to *Discinocaris* from the Moffat Shales, but the anterior angles of the cervical suture are more rounded in the Eifel specimen and the striation is coarser.

### 4. *Cardiocaris bipartita*, mihi, sp. nov. Plate IX. Figs. 14 and 15.

The two forms I have here distinguished are very near to *C. Rœmeri*, but they have a tolerably well-marked dorsal suture which that species lacks; they are also widest in front. The depth of the V-shaped fold of the cervical suture is rather more than one-third the length of the shield, whereas in *C. Rœmeri* it occupies considerably less than one-third.

The concentric striæ are distinctly marked, but no radiating striæ are visible.

| | | | | |
|---|---|---|---|---|
| Fig. 14. | Breadth | 15 mm. | Length | 25 mm. |
| Fig. 15. | „ | 17 „ | „ | 30 „ |

## II. *Pholadocaris*, gen. nov.

### 5. *Pholadocaris Leeii*, mihi, sp. nov. Plate IX. Fig. 16.

This singular shield differs greatly in form from every Phyllopod hitherto noticed.[1] In its narrowness it resembles *Caryocaris Wrightii* of Salter from the Skiddaw Slates (see Quart. Journ. Geol. Soc. vol. xix. 1862, p. 139, fig. 15); and but for the fact that the two sides of the shield are united behind by a wedge-shaped dorsal portion, they might readily be supposed to be the two outspread valves of some *Pholas* or *Leda*-like molluscan shell. The carapace, which is 25 mm. in length by 15 mm. in breadth, has an almost wedge-shaped contour, being widest anteriorly. The front of the shield measures 10 mm. across its cephalic portion, represented by the V-shaped cervical sinus, which is also 10 mm. deep. Behind the cervical notch, is a small elliptical area 5 mm. long and 4 mm. broad (reminding one of the *lunule* of a bivalve shell), having a slightly-raised border; from this area two strongly-marked furrows, commencing 1 mm. apart, pass backwards, diverging gradually to 4 mm. distance from each other, where they join the posterior border. The space between these two furrows is marked by about 10 delicate raised striæ, which diverge slightly like the furrows themselves towards the posterior margin. The lateral portions of the carapace are ornamented with very minute radiating and concentric striæ.

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[1] Whilst these notes were passing through the press my attention was obligingly directed by my colleague, Mr. R. Etheridge, jun., to a singular form of Phyllopod-shield recently described by him, in Part II. of a "Monograph of the Silurian Fossils of the Girvan District," 1880, pp. 207-210, pl. xiv. figs. 17-20, which is singularly like our Eifel fossil. It is named by him *Pinnocaris*. It differs chiefly in its much greater breadth in front, and in being shorter in proportion, and the dorsal line is straighter than in *Pholadocaris*. Another form named *Solenocaris strigata* by Meek (see Geology of Ohio, Columbus, 1875, Palæontology, Part II., p. 321, pl. 18, figs. 4 *a b c*) is equally narrow, but the striæ are differently arranged, and render this form quite distinct. *Solenocaris* was already preoccupied by Mr. J. Young for a Scottish form from Girvan in 1868 (see op. cit. p. 207).

This is the only specimen I have seen from this locality, and I dedicate it with great pleasure to my friend Mr. John Edward Lee, F.S.A., F.G.S., with whom I passed so many agreeable days in the Eifel-district.

### III. Genus *Aptychopsis*, H. Woodw. 1872. Geol. Mag. Vol. IX. p. 564.

### 6. *Aptychopsis Salteri*, mihi, sp. nov. Plate IX. Fig. 17.

In my report to the British Association, Brighton, 1872, and in the Geol. Mag. Vol. IX. 1872, p. 564, I gave a notice of several new Phyllopod shields from the Middle Silurian of Hawick, Roxburghshire, three of which I referred to a new genus *Aptychopsis*, and named severally *A. glabra*, *A. Lapworthi*, and *A. Wilsoni*. The last of these is the form which, in point of size, agrees most nearly with the fossil figured in our Plate, Fig. 17, which was obtained by Mr. John E. Lee from the Upper Silurian (Wenlock Shale) of Pencarreg,[1] Caermarthenshire.

This specimen, which exhibits one side of a Phyllopod shield, was marked by the late Mr. J. W. Salter, F.G.S., as the "semi-operculum of a large *Orthoceras*." Although the operculum of *Orthoceras* remains unknown, we are now well acquainted with these Phyllopod shields from many localities, and I have every confidence in referring this fossil to the genus *Aptychopsis*.

In this specimen the carapace is 35 mm. long, by 25 mm. wide; the V-shaped cephalic portion is 10 mm. deep, and the posterior dorsal line is 25 mm. long. The surface of the carapace is finely striated concentrically and the lateral border of each valve seems to have the edge bent downwards and to have been slightly concave. This is a more oblong form than *A. Wilsoni* and the angles of the V-shaped cervical suture are sharp in the Welsh specimen, but rounded off in the Scottish example, which is also a more circular form.

I venture therefore to separate this specimen from Pencarreg specifically from the Roxburgh examples, and have designated it

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[1] Mr. Lee spells this place "Penkerrig" on the label.

*A. Salteri* in memory of my late fellow-worker in the Palæozoic Crustacea, Mr. J. W. Salter, F.G.S., for so many years Palæontologist to the Geological Survey of Great Britain.

*Formation.*—Upper Silurian (Wenlock Shale).

*Locality.*—Pencarreg (or "Penkerrig"), Caemarthenshire.

### EXPLANATION OF PLATE IX.

Figs. 1—7. *Cardiocaris Rœmeri*, H. Woodw., sp. nov.
„ 8—12. ———— *veneris*, H. Woodw., sp. nov.
„ 13. ———— *lata*, H. Woodw., sp. nov.
„ 14 & 15. ———— *bipartita*, H. Woodw., sp. nov.
„ 16. *Pholadocaris Leeii*, H. Woodw., sp. nov.
„ 1—16 from the Upper Devonian, Büdesheim, Eifel, Rhenish Prussia.
„ 17. *Aptychopsis Salteri*, H. Woodw. sp. nov. Upper Silurian (Wenlock Limestone), Pencarreg, Caermarthenshire, S. Wales.

All the specimens are figured of the natural size, and are from the Museum of Mr. John Edward Lee, F.S.A., F.G.S., Villa Syracusa, Torquay.

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## II.—First Impressions of Assynt.

By Wilfrid H. Hudleston, M.A., F.G.S.;
President of the Geologists' Association.

It must be admitted that first impressions are to a certain extent instinctive, and need not, therefore, be taken for more than they are worth. To do any really valuable work in such a troubled district as Assynt would require a considerable length of time. Still, after having been nearly a fortnight in the place—a fortnight in which the rainy days and the dry ones were about equally balanced —it is almost impossible to avoid forming some idea as to the respective merits of the interpretations which have been put forth. And this one is all the more apt to do in order to be able to institute comparisons with other districts of the North-West already visited in previous years.

Furnished with Professor Heddle's excellent geological map of Sutherland (Mineralogical Magazine, No. 21), and furthermore enjoying the society and experiences of the Professor himself, I arrived, on the last day of July, in the wild and remote corrie which flanks the north side of Ben More, having walked that morning from the head of Loch Shin over peaty moors which for the most part hide all the rocks.

After wading across the upper Cassley between Fionn Loch More and Fionn Loch Beg, and after toiling through a maze of glacial debris and peat hags, we struck the solid rock at perhaps 1400 feet above the level of the sea. From this point it is easy to perceive that the east slope of Ben More is covered with quartzite, but I was surprised to find that the bulk of the rocks in the corrie, which lies beneath the northern slopes of Ben More and Coniveall, consists of a peculiar gneissic rock which Dr. Heddle terms the "Logan" rock. Some portions of this "Logan" rock are very puzzling, more especially in its relations to a dark green or dull black aphanitic rock which Dr. Heddle at one time was disposed to regard as igneous. Continuing to ascend towards the Bealloch between Coniveall and the peaks of Na Touadhain, although we saw quartzite occupying the heights on both sides, still for a long distance there was nothing but "Logan" rock to walk upon except in one spot, where a large mass of quartzite was apparently faulted on to it. At length having arrived at an elevation of about 2500 feet, this everlasting "Logan" rock gave place to a fragmental series of quartzo-felspathic grits, with some beds of coarse conglomerate, having large and well-rounded pebbles of vein quartz. This series, I was told, is regarded as constituting the basement beds of the Upper Quartzite, which forms the summits of the mountains hereabouts, including, besides those already named, Ben Uarran, Ben Uie, etc.,—a white and dazzling wilderness of quartzite blocks. From this elevation of about 2600 feet we descended rapidly to Inchnadamph, some 230 feet above sea-level.

*Local Topography, etc.*—Inchnadamph, at the head of Loch Assynt, is a centre from which several of the most critical sections may be visited. It lies in what I may term a longitudinal hollow, running north and south, between two mountain ranges. The *western* range consists of a chain of disconnected heights, of which Quinaig, Canisp, Suilven, and Coul More are the culminating points, each separated by a deep lake-filled basin. This chain of heights, though nowhere reaching an altitude of 3000 feet, is a terrible condenser of moisture, and the mysterious gloom of its almost ever-clouded summits serves to exaggerate the altitude of these weird precipices. The *eastern* range is far higher, and, instead of being seamed by transverse valleys cut down to within two or three hundred feet of the sea-level, presents a tolerably continuous series of ridges, only separated by lofty passes (Beallochs). This eastern range may roughly be described as extending from the sea loch of Glen Coul on the north to the inland Loch Borrolan on the south. The familiar names of Glasven, Ben Uie, Ben Uarrau, Coniveall, Ben More, and Breabag represent portions of the mass, which may be regarded as the largest mountain group in Sutherland. Ben More and Coniveall, which really are peaks of the same ridge, attain elevations of 3273 feet and 3234 feet respectively.

It is this eastern range, so massive, so rugged, and so lofty, which causes the geology of Upper Assynt to be thus difficult of interpretation beyond, one might almost say, any district in the North-West. The complexity of folding to which this mountain group has been subjected is surprising, and nothing but time and patience can adequately unravel its mysteries.

*General Structure of the Western Range and Longitudinal Hollow.*—The geological structure of the western range is on the whole simple. From the "dark tumbled sea" of Hebridian gneiss there rise the deeply intersected masses of Torridon Sandstone, succeeded unconformably, according to most observers, by a massive Quartzite dipping to the eastward in regular sheets, which for large distances are almost coincident with the easterly slope of the mountains themselves. This may be regarded as the normal state of things, and may be seen by any one driving along the road from Loch Glen Coul, opposite Quinaig, by way of the head of Loch Assynt and Stronchrubie, to Craig-a-Knockan, opposite Coul More. It is true that near Ledbeg, along this line of road. there is some deviation from the normal state of affairs, but the fact of there being "Logan" rock exposed in the vicinity is quite enough to account for the deviation, as, wherever there is "Logan" rock, trouble is sure to ensue.

So far, then, the geological sequence is tolerably clear. This Quartzite has intercalated bands of igneous rock, and dips regularly towards the longitudinal hollow which separates the western from the eastern range. There can be little doubt that the hybrid group of rocks known as the "Fucoid Beds" succeed in regular order. These beds are mixtures—chiefly fine-grained grits often with a considerable proportion of carbonates, usually blue-hearted, and weathering yellow: hence the term "yellow beds" is applicable on exposed outcrops. As there is so little alteration, these are just the beds for fossils, but only "Fucoids" and "Serpulites"[1] have as yet been found. The former are very abundant. Beds of tolerably pure quartzite, and even of dolomite, occur sometimes in this group. Such quartzites, however, have nothing to do with the supposed Upper Quartzite, whose position, if it exists at all, must be above the main mass of Dolomite, which succeeds the "intermediate" series.

These dolomites generally occupy the escarpments which immediately flank the east side of the longitudinal hollow, and may be well studied, among other places, in the Stronchrubie cliff, which rises about 450 feet above the road. The lowest beds there seen are dusky dolomitic rocks, granular or compact, and very fœtid. They contain noticeable traces of carbonaceous matter, and are tolerably free from insoluble rock *débris*, at least the sediments are very fine. At this place a kind of diorite is seen to be interbedded with these dusky rocks, which are succeeded by grey dolomitic limestones, becoming paler in colour towards the top. Up to this point everything seems clear and simple; yet a thorough examination of this Quartzite-dolomite group, with accurate measurements and careful lithological notes, especially with reference to the number and nature of the bedded "igneous" rocks, would be very useful. It may not be practicable to get the whole group in one section, but suitable places might be selected for examination of portions, avoiding as much as possible places where a hollow covered with vegetation intervenes, and above all, in putting the pieces together, *nothing should be taken for granted.*

Very shortly after reaching the edge of the plateau, the dolomitic limestones are seen dipping at a very high angle, and further eastward they dip in a very different, though not exactly opposite direction. A certain amount of these very irregular dips may be due to percolation of water and unequal solution, yet much also is due to the general stratigraphical confusion which here begins to prevail—a prelude to the still more terrible confusion of the eastern range whose roots we are now approaching.

[1] From an examination of two hand-specimens of a white grit, or quartzite, full of the so-called "*Serpulites? Maccullochii,*" Salter (see Quart. Journ. Geol. Soc. 1858, p. 381, pl. 13, fig. 31), I venture to think that their appearance is highly sugges[illegible] of crinoidal fragments.—Edit. Geol. Mag.

*The Eastern Range.*—This is the real field of battle, out of which three issues at least have to be decided. 1. Is there an Upper Quartzite? 2. What is the nature and geological position of the "Logan" rock? 3. Is the Upper Gneiss really a newer formation properly overlying the Quartzite-dolomite?

1. *Is there an Upper Quartzite?*—There are quartzy beds in the "intermediate series," and possibly, in some places, in the Dolomite itself; but the real question is, whether the important rock masses referred to the Upper Quartzite are not repetitions of the series below the Fucoid Beds. One thing is pretty clear, that, in this district at least, where there is no "Logan" rock, there is no Upper Quartzite.

Thus at Craig-a-Knockan the sequence seems clear enough. The Quartzite dips steadily to the eastward from Coul More, and is regularly overlaid by the "intermediate series" with its Fucoids, "yellow beds," quartzy beds and impure dolomites, and the whole is surmounted in the cliff-section by the Dolomite just as at Stronchrubie. The great difference consists in the fact that the Upper Gneiss comes on at once, so that there is no room for an Upper Quartzite. Of course it is open to the believers in an Upper Quartzite to say that it was never developed, or has been denuded off previous to the deposition of the overlying beds at this particular spot.

But let us now revert to more disturbed ground, and, in fact, to Murchison's type section at the head of Loch Assynt, known as the Cnoc-an-drein section.[1] This commences in the bottom of the longitudinal hollow between the two ranges, and ascends in an east-north-east direction. It is to the lower portion only that I would direct attention. Matters are not so clear as in the Stronchrubie and Craig-a-Knockan escarpments, where, as we have seen, no Upper Quartzite presents itself. Here, at a short distance from the Post Office of Inchnadamph, the dusky dolomites associated with a peculiar kind of diorite succeed the intermediate series, and these again are succeeded by the pale grey dolomites dipping moderately E.N.E. The ground is broken, but gradually rises, the dips being inwards. A bed of igneous rock is again seen to intervene, and then a sudden rise in the ground is observed to be composed of compact quartzite, with approximately the same dip as most of the underlying beds.

The whole thing seemed all right, and I could not deny that appearances were in favour of there being an Upper Quartzite at this place, though my first question was, what has become of the peculiar grit and conglomerate which underlies the presumed Upper Quartzite of Ben More? We continued to pass over successive beds of this Quartzite all dipping into the hill. In it there are three beds of igneous rock, each of which may be recognized by certain peculiarities, though on the whole the type is not dissimilar from what occurs in the dolomite.[2] Just above the third igneous bed the Quartzite suddenly becomes vertical, and ultimately assumes a dip opposite to the one below, so that, as one continues to ascend, the same beds are again passed over. This is admirably shown by the different bedded igneous rocks, which now reappear in reversed order. With such evidences of rolling over and instability of dip, one is naturally led to question the value of the apparent superposition of the Quartzite to the Dolomite, which is seen below, though it would be going too far to say that the evidence of this section in favour of the existence of an Upper Quartzite is altogether to be discarded in favour of the notion of a reversed fault at the junction. This is the only place seen by me where there could be any grounds for requiring the existence of an Upper Quartzite.

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[1] Q.J.G.S. vol. xvi. p. 217, and vol. xxxvii. p. 242.

[2] Subsequent examination would lead one to suppose that porphyritic structure is more frequent in the interbedded igneous rocks of the Quartzite.

In the great mountains of the eastern range there really seems very little evidence of the true stratigraphical relations of the vast beds of Quartzite to the fragments of Dolomite, which are pitched about in all directions on some of the lower grounds. As far as one can judge from such a chopped-up district, it would seem that there is a very considerable convergence of dips towards Loch Maolach Corrie, and thus that the Quartzite, *on the east* of the large area of dolomitic limestone thereabouts, *underlies* the limestone just as it does on the west. It follows, therefore, that the Quartzite of Breabag, etc., is a mere repetition, possibly with some thickening, of the regularly bedded Quartzite of the western range usually known as the Lower Quartzite.

But, quitting individual sections, there remains the general impression derived from an inspection of geological maps, and based upon the presumed continuance of an easterly dip in all the beds, that those quartzites occurring to the east of the dolomite escarpment must be Upper Quartzite, unless the contrary can be shown. It is just possible, however, that the explanation which fits so well for the Quartzite of Breabag may, with modification, apply along the whole line. This supposes a roll up of the Lower or western Quartzite in a series of convolutions to the east of the Dolomite which has been assumed to pass beneath it. Much stress has been laid upon the presumed lithological differences between the Lower and the alleged Upper Quartzite. As far as I could see, these differences amount to very little, their leading features, even to the purplish colour of some of the beds, appearing very similar.

2. *What is the nature and geological position of the "Logan" rock?*—This mysterious rock has had so many aliases that its individuality, as identified by various writers, runs some risk of being lost. Prof. Heddle has given an excellent summary of the different views respecting it,[1] and in a paper read before the Royal Society of Edinburgh, on the 17th July last, he assigns the following sequence to the rocks of the North-west Highlands:—Torridon Conglomerates, Lower Quartzite, Dolomite Series, "*Logan*" rock, Upper Quartzite, Upper Gneiss.

It may well happen that in the long range from Whiten Head to the Sound of Sleat more than one class of rock has been enumerated under this head. At present we are more especially concerned with the Assynt district, though the term "Logan"

[1] Mineralogical Magazine, No. 22, p. 43 *et seq.*

requires an explanation necessitating reference to other localities. It is in fact the "igneous" rock of Nicol and Murchison, which plays such an important part in confusing the geological structure of the country and the sequence of the beds; so that it may be looked upon as one of the prime authors of the controversy on the North-West succession, and a most difficult nut to crack. This kind of rock is well developed in Glen Laggan or Logan near Loch Maree, where it is very accessible in the bed of the stream. A few years ago I ventured to point out[1] some of the peculiarities of this rock, and referred especially to the strings of epidosite which pervade it. From its association with other bedded masses, and from its general appearance, I came to the conclusion that it was "an old gneiss partly invaded by extravasated matter." In the following year Professor Bonney visited the same district, and, in describing this very rock, went a step farther and classed it with the regular Hebridian gneiss.

This "Logan" rock occupies a large surface in the Assynt country, and more especially in the eastern range, of which Ben More is the highest peak. A glance at Dr. Heddle's map of Sutherland will at once show its importance in this area—an importance which could hardly be gathered from an inspection of Professor Geikie's general map of Scotland. But large as this area is, it might be extended in the great corrie on the north side of Ben More previously mentioned. Dr. Heddle controverts the views that it can either be the older gneiss, or an *eruptive* igneous rock: he regards it as conformably interbedded, its horizon being chiefly between the Dolomite and the Upper Quartzite.

I confess that, with every wish to accept my kind friend and cicerone's reading, I was unable to endorse this position, and would much rather fall back upon a modification of Nicol's interpretation of the district, as exhibited more especially in his section of Glasven.[2] This, if we omit an inch from the east end, is not an unfaithful representation of the appearances both about Loch Glen Coul and Glasven, when certain modifications are made. The "syenite" of Nicol, in this section, represents the position of the "Logan" rock, and he is probably not so far wrong in representing the Quartzite (which should however have a capping of "yellow beds" if not of regular Dolomite) as merely *abutting* on the rounded knolls which rise up behind. The true continuation of the broken-off ends must then be sought in the so-called "Upper" Quartzite which prevails at greater heights to the eastward.

It would be far too long a story to go into details on this important point, viz. the junctions of the Quartzite-dolomite with the apparently overlying "Logan" rock. Dr. Heddle has discovered a remarkable section in the most precipitous cliff on the south side of Loch Glen Coul, about a mile or so from the head of the Loch, to which section he conducted Dr. Callaway and myself. Here the dolomitic series, considerably modified perhaps in its development,

[1] Gneiss Rocks of the North-West Highlands, Proc. Geol. Assoc. vol. vi. p. 75.

[2] Q.J.G.S. vol. xvii. p. 95.

is seen to pass *under* the "Logan" rock, the angle of dip being about 28°. It is true that the beds in immediate contact are not very typical representatives of "Logan" rock, but the great gneissic masses very soon come on in force. Further eastwards the line of the dolomitic series may be traced in almost vertical masses across the head of the Loch. Geologists can hardly draw any absolute conclusions from this place alone; but whilst some see in the above indications a conformable upward sequence, others will suspect the presence of an inversion. In its general effects this latter would produce almost the same results as if the Quartzite-dolomite merely abutted against the "Logan" rock in the way supposed by Nicol.

What is the "Logan" rock petrologically? If we are to take this very district of Glen Coul, we find plenty of red orthoclase, of quartz and felspar, and of hornblende, sometimes in foliations, sometimes massive. Other varieties also occur, but one of the most difficult tasks is to make out any definite system of divisional planes, which might be regarded as showing the bedding, so as to determine the dip and strike. I hold in my hand at the present moment a thoroughly typical specimen of "Logan" rock obtained from the somewhat isolated exposure to the west of Ledbeg. It is striped something like a tiger, with bands of a hackly pinkish felspar, partially relieved by dull white quartz, alternating with thick or thin bands of a dark-green matted hornblende. The cracks and backings are lined with abundance of pale green epidosite, which is so characteristic of the rock in the Logan valley. Altogether this is a fair specimen, though there are others far richer in quartz. I have usually been disposed to regard the abundance of epidosite as one of the features of the "Logan" rock which especially distinguish it from the Hebridian Gneiss, but Dr. Heddle states[1] that this peculiar mélange occurs in greater quantity and perhaps in a purer state in the west of Ross-shire than in any locality known to him. This is in the Hebridian Gneiss near Poolewe. Hence this presumed distinction vanishes.

Although, therefore, there are certain differences in the aspect of hand specimens, and still more perhaps in the general character and behaviour of large masses, yet the "Logan" rock appears to me to possess more resemblance to the Hebridian Gneiss than to any other formation in the district. There must be differences, however; otherwise so acute an observer as Nicol would hardly have continued to call this rock "granulite," "syenite," "diorite," according to the district he was describing. In Assynt his "Logan" rock is mostly "syenite," and he appears to have regarded it as intrusive. It is probably owing to the circumstances connected with its appearance in the position now occupied by it in the Assynt mountains, and largely also to partial injection by local extravasations and to crushing during folding, that the main points, in which the "Logan" rock differs from ordinary Hebridian Gneiss, arise. And yet I hesitate whilst writing this, bearing in mind that Dr. Heddle, who knows both rocks so well, does not perceive the relation, which always struck me as subsisting between the two, though I am far from saying that they are absolutely identical.

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[1] Min. Mag. No. 20, p. 211.

What then is the function of this "Logan" rock throughout the eastern range of Assynt from the precipitous shores of Loch Glen Coul to the termination of the range near Loch Borrolan? Is it not in reality the framework or core round which the newer formations are folded, sometimes in great winding sheets of white quartzite like those in which Breabag is swathed? Not that these were ever deposited upon their base, whatever it may have been, in its present position. That base has been elevated to the heights it now occupies in the crush which has produced these convolutions and dislocations. The general result of these movements seems to have been the establishment of an irregular synclinal in the longitudinal hollow between the west and east ranges, so that the gently sloping Quartzite of the one reappears in all sorts of positions round about the sides and summits of the other, with fragments of the Dolomite occurring in the most unexpected places and in every attitude. In such a hill as Breabag the framework does not show through the clothing, the Quartzite is unbroken, and wonderful has been the plasticity of the rock which could endure without fracture such foldings as may be seen in the Bealloch between that mountain and Coniveall. It is probable also that the thickness of the Quartzite itself varies materially within short distances.

The explanation of a core of gneiss very well suits the appearances on both the north and south sides of the ridge connecting Coniveall with Ben More. It will be remembered that on the north side "Logan" rock continues beneath this ridge to a height of about 2500 feet, before the grits and conglomerates succeed, which lie at the base of the presumed Upper Quartzite on this mountain, but nowhere else as far as I can make out. The same phenomenon may be noticed on the south side in the wild corries round Dhu Loch More. "Granitic gneiss, and mica slate with intrusive rocks," says Nicol,[1] "constitute the nucleus of the mountain." His granitic gneiss and mica-slate are, I apprehend, nothing more nor less than our "Logan" rock, which extends to an elevation of about 2550 feet (by aneroid) on the S.E. shoulder of Coniveall. At this point the usual granitic and hornblendic assortment of crystalline rocks, varied by a little porphyry in places, suddenly terminates, and is succeeded by the coarse fragmental series underlying the Quartzite. These beds dip 25° W.N.W., *i.e.* rather into the mountain, which may receive strength from a slight local syncline. Thus on both sides an elevation of at least 2500 feet must be claimed for the "Logan" rock of the Ben More-Coniveall group, leaving about 700 feet for grit beds, conglomerates, quartzites and the like.

It was the sight of this magnificent corrie at the head of Dhu Loch More, with the entire sweep of its precipitous slopes, thus obviously composed of "Logan" rock, with a mere capping of Quartzite, which at once staggered my faith in the Murchisonian interpretation of

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[1] Q.J.G.S. vol. *cit.* p. 99.

Assynt. I admit that there are plenty of difficulties still, and that much has to be explained which I had no time to see. These are but first impressions; yet I should be very loath to believe that, because a few sections may seem to show some tortured and dislocated fragments of the Quartzite-dolomite appearing to pass under "Logan" rock, that this great and continuous mass is not really from top to bottom the local representative either of the fundamental gneiss, or of something that is first cousin to it. This is the conclusion which seems to render a part at least of the sequence in Assynt intelligible, though the notion of an intercalated "Logan" rock, which has not a few supporters, may work better in other districts.

3. *Is the Upper Gneiss really a newer formation, properly overlying the Quartzite-dolomite?*—This, after all, is the most important question, but I had no opportunities of studying it in the mountains of Assynt. South of the line of Loch Borrolan there is an immense change in the geological features of the country. The "Logan" rock ceases to appear and the great range of Ben More seems to have died away in the red syenite of Loch Borrolan, where it attains an elevation of 1300 feet in Cnoc-na-Sroine. Most people regard this as an igneous intrusive rock, and such it probably is, though with a strong affinity for "Logan" rock, which it most likely injects and partly perhaps passes into. Anyhow the great eastern chain of Assynt which I have endeavoured to describe fails to the south of this line.

An important extension of the Upper Gneiss to the westward at moderate elevations is the immediate result, and we are thus enabled to see the stratigraphical relations of this group to the Quartzite-dolomite under favourable conditions. Allusion has already been made to the section at Craig-a-Knockan. If to see is to believe, there ought not to be much difficulty here. The Quartzite sweeps steadily down from Coul More, and is succeeded in ascending order by the "yellow beds," and these by the Dolomite, the whole having moderate easterly dips, just as is shown in Professor Geikie's section.[1] The junction with the Upper Gneiss, which succeeds, seems perfectly regular, the direction of dip being still about the same and not exceeding 10°. In the place where we saw the junction, along the line of which we walked for some distance, there are no appearances such as would justify Nicol's interpretation. In one place the Upper Gneiss is very much crushed and full of pyrites, but there is certainly no turning-up of the Dolomite, which may be seen for some distance to underlie the so-called Upper Gneiss conformably and at a moderate angle. It is for the students of Archæan geology to upset the plain evidence of this section, which certainly seems to mean what it says. Indeed, the beds hereabouts slope at such a moderate angle, and there are so few signs of dislocation, that one is scarcely prepared for an inversion, such as may well occur in the troubled region of Ben More.

There is only one other place where I had an opportunity of visiting the junction of what is usually regarded as Upper Gneiss with the Quartzite. This was at the Stack of Glencoul (about 1700 feet), where the Dolomite is absent. No actual contact was observed here, but the direction and amount of dip of the two formations are, as far as I remember, about the same; and, what is more, there really seems to be a sort of lithological passage between the regular Quartzite and the fine quartzose flags which gradually conduct to the more micaceous beds. I may be wrong, as the spot is very remote, and only accessible after fatigues which rather impair one's powers of observation.

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[1] Q.J.G.S. vol. xvii. p. 180.

*Conclusion.*—There are several minor points on which I have not touched. One of these is the relation of the Ledbeg Marble to the Dolomite. These marbles are fragmentary masses lying somewhat in the direction of the strike of the Stronchrubie Dolomite, and apparently associated with Quartzite, which is hemmed in between a ridge of "Logan" rock on the west and the so-called porphyry of Loch Borrolan on the east. These marbles effervesce with acid far more readily than do the dolomites, and from this I infer that the carbonate is principally lime. On the other hand, they contain a considerable development of silicates, either serpentine or malacolite—perhaps both. The magnesia in these beds, therefore, may exist in combination with silica rather than with carbonic acid. One can hardly say whether the difference between these two groups is one of origin, or merely superinduced through contact alteration, as was suggested by Nicol. The subject is an interesting one, but requires close attention and a careful examination of numerous specimens. It certainly seems a little far-fetched to go in search of another geological formation, in which to locate these curious and by no means extensive fragments.

There is another observation which my short trip to Sutherland has induced me to make, viz. that the local strike of beds cannot always be accepted as an indication of the group to which they belong. There has been too much dogmatism on this point. It is quite possible that a *prevalent* strike exists for certain groups, but the exceptions to the direction of this are so numerous, especially in the more disturbed districts, that no one should pretend to be guided by the strike alone to any conclusions of importance with reference to the grouping of beds in limited areas.

It is not without feelings of regret that I cannot see my way to an Upper Quartzite, and if I have been wrong about the position of the "Logan" rock, I still think that this monster will, in most places, have to be dealt with on the basis of a fold over of some of the lower beds. The sequence at Craig-a-Knockan, showing the superposition of the Upper Gneiss, seems to be unshaken.

There are workers now in the country, skilled in the interpretation of the older rocks. May it be given to them effectually to pierce the mists of Assynt, and to raise the veil which yet hangs over portions of the North-West!

## III.—ON THE CAUSE OF THE DEPRESSION AND RE-ELEVATION OF THE LAND DURING THE GLACIAL PERIOD.

By THOMAS F. JAMIESON, F.G.S.

IN a paper published in the Quarterly Journal of the Geological Society for January, 1865, p. 178, I drew attention to the remarkable fact that in various parts of the world the presence of glaciers had been attended by a submergence of the land, and I suggested that the enormous weight of ice laid upon the surface of the country might have caused a depression, while the melting of the ice would also account for the rising again of the land which seems to have everywhere followed some time after the ice disappeared.

The paragraph in question, if it did no other good, was of service in so far as it attracted the attention of the thoughtful mind of Dr. James Croll, who in a letter dated 22nd Aug. 1865, addressed to Professor Ramsay, and published in the pages of "The Reader" of the 2nd Sept. in the same year, commented on the suggestion I had made. But, while admitting the fact that submergence had generally accompanied glaciation, he doubted the sufficiency of the cause I had assigned, and maintained that the circumstance would be better explained by the influence of a great polar ice-cap whose mass would effect a slight shifting of the centre of gravity of the earth and thus draw the waters of the ocean northward or southward, according as either pole happened to be under ice at the time. This theory had previously been advanced by M. Adhemar and developed by him at considerable length, in a volume entitled "Revolutions de la Mer."

Dr. Croll's letter gave rise to a lengthened correspondence and controversy in the pages of the periodical called "The Reader," in which a part was taken by Mr. S. V. Wood, jun., Mr. O. Fisher and others; but so far as I remember, no further notice was taken by any of them of the cause I had suggested.

Dr. Croll's maturer views on the subject will be found set forth in his remarkable work called "*Climate and Time,*" and also in a paper published in the GEOLOGICAL MAGAZINE for July and August, 1874, "*On the Physical Cause of the Submergence and Emergence of the Land during the Glacial Epoch.*" He there assumes that the Antarctic contingent is at present covered by a cap of ice 2800 miles in diameter and six miles thick at the pole, with an average depth of about two miles all over; and he maintains that the submergence of the northern lands during the Glacial period was caused by the transference of this great mass of ice from the southern to the northern hemisphere.

It seems to me that we have no sufficient proof of the present existence of a south polar ice-cap of the dimensions Dr. Croll assumes; and the evidence, so far as I can judge, seems to be decidedly against the notion that there was any such ice-cap at the North Pole during the Glacial period; but without meaning to question the adequacy of a great polar ice-cap, supposing it did exist, to affect the centre of gravity of the earth to some degree, and thereby to cause a sensible change in the sea-level, I shall here mention a few objections that present themselves to the application of this theory made by Dr. Croll.

1st. The evidence of submergence we find in the shape of raised sea-beaches, and beds of clay and sand containing marine fossils, seems to show that during the time of their formation no such immense cap of ice could have existed in the North Polar area, nor in any of the glaciated regions of the northern hemisphere with which we are acquainted. These elevated marine beds have been traced by the Arctic Expeditions along the shores of Greenland and Grinnell's Land up to lat. 82°, within a few hundred miles of the Pole itself, proving that during the time they were laid down no great ice-cap could have existed there, and showing that even in Greenland much of the coast was covered with sea-water and not by ice. Again, in Norway and Sweden the marine glacial beds show that during the time of their formation, the land-ice in Scandinavia was much circumscribed, and had retreated far within the present line of shore. In our own country also the Arctic shell beds found in Wales, Lancashire,[1] and various parts of Scotland and Ireland, demonstrate that the ice had shrunk into comparatively small dimensions, and did not cover anything like the present area of the British Isles. The same holds good in America, where the marine clays and sands found along the banks of the Ottawa, the St. Lawrence, Lake Champlain and Labrador afford convincing proof that the great Canadian glacier had dwindled into comparative insignificance at the time they were deposited. I am therefore unable to see where the enormous mass of ice could have lodged that Dr. Croll calculates upon; for during the time of submergence to which these marine beds belong the land-ice of the northern hemisphere, instead of being at its maximum, was so far reduced as to be evidently inadequate for the purpose he requires. The submergence according to his theory must have diminished step by step with the diminishing ice; for the action of gravitation he invokes operates instantaneously, and the submergence could not have endured a day after the ice vanished.

2nd. If the submergence was caused by an ice-cap drawing the ocean northward, the sea-water should have risen to equal heights along the same parallels of latitude, but the facts hitherto reported do not agree with this at all, for they indicate a very unequal amount of submergence in places situated in the same latitude. The best-known high-lying marine beds of New England and Canada lie between lat. 44° and 52°, which corresponds to that of France and the South of England, just where evidence of submergence is conspicuous by its absence. Again, we find in Scandinavia evidence of submergence to the extent of 600 or 700 feet, but in the same latitude along the eastern side of the Baltic and in Finland no evidence of a like submergence has been found. In the neighbourhood of Dublin, Lancashire and North Wales, sea shells are found in the superficial beds of sand and gravel to heights of 1200 and 1350 feet, but no evidence of submergence to anything like this extent has been detected on the eastern side of England or in the neighbouring parts of Europe. In Canada the marine shell beds reach up to 470 feet at Montreal, but, says Mr. Thos. Belt,[1] "going eastward from Montreal the elevation of the marine beds, marking the former submergence of the land, gradually decreases until in Nova Scotia it reaches zero." Dana, in the 2nd edition of his Manual of Geology, tells us that the altitude of the marine deposits on the southern shores of New England is 40 or 50 feet, at Lake Champlain (which is in the same lat. as Nova Scotia) they occur up to 393 feet. It would therefore appear that on the Eastern coast of North America the submergence, like the glaciation, extended farther South than it did in Europe. This is quite intelligible if there was a depression of land caused by the glacier, but is unaccountable by a rise of the ocean.

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[1] Macclesfield, Cheshire, see GEOL. MAG. 1865, Vol. II. pp. 293-299.

3rd. Again, according to Dr. Croll, the amount of submergence should have diminished very very gradually as we trace it from north to south. For example, he calculates that if the submergence was 485 feet at the North Pole, it would be 434 feet in the lat. of Edinburgh, or only 51 feet less. The evidence, however, does not agree with this, for in Holland, Belgium, France, and the South of England little or no submergence has been discovered, although a large amount occurred a few hundred miles to the north of these places. In Scandinavia the highest lying shell-beds are in the southern half of the peninsula, where they attain an altitude of 500 or 600 feet, but in going northward from Trondhjeim they seem to decrease in elevation, and in Finmark none have been discovered at nearly so great a height. At Hammerfest, according to M. Bravais, the highest of the old sea beaches is only 92 feet. This is inconsistent with Dr. Croll's theory, according to which the submergence should have increased to the north instead of growing less, but it is intelligible on the ice pressure hypothesis, as the amount of precipitation is greatest along the south half of the Norwegian coast and therefore the weight of ice would be heaviest in that quarter.

Moreover, Bravais found that the old sea beaches in Finmark are not horizontal. If this be correct, it is a good proof that the movement has been due to a rise of the land, for had it been caused by a fall of the ocean it is evident the old beaches should have been horizontal. Bravais found his uppermost beach line decline in level from 221 feet at its southern extremity in Altenfiord to 92 feet at its northern end at Hammerfest, thus lowering in level from south to north.[2]

These objections to the theory of Dr. Croll induce me to think that the cause assigned by him is not the true one, and that an explanation must be sought in some other direction. I may further remark that Dr. Croll's theory assumes that the glacial conditions were not simultaneous in the Arctic and Antarctic regions. But in the present state of our knowledge it seems to me that we are not entitled to make this assumption, for I do not know of any trustworthy evidence to show whether the glacial conditions were or were not simultaneous in both hemispheres. At present we cannot tell.

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[1] Trans. of Halifax Institute, 8th May, 1866.

[2] Quart. Journ. of the Geol. Soc. vol. i. p. 541.

Supposing, however, we grant an ice-cap at one pole of the size Dr. Croll requires, viz. six miles thick at the centre, or about 32,000 feet. This would give a weight of 12,000 lbs. on the square inch, which is equal to 800 atmospheres, and would amount to more than 21,000 million tons on the square mile. Could the bottom layers of ice sustain such a weight without liquefying? Supposing even this to be possible, would not such a weight depress the ground beneath it? Would not the centre of gravity of the earth be more likely to pull the cap down than the cap to shift the centre of gravity? The earth would require to be a very rigid body indeed to sustain such a weight for thousands of years without yielding.

I, however, prefer resting my objections on the geological evidence, which I think conclusively shows, from the unequal amount of submergence in adjoining areas, that the circumstance was not occasioned by a rise of the sea, but by a fall of the land. I shall afterwards point out that we have also a good deal of evidence of depression in regions where there was no submergence, and therefore where movements of the sea do not enter into the question at all.

## HYPOTHESIS PROPOSED.

It seems to me that the facts agree better with the notion that the submergence was due to a sinking of the land, and my idea is that the ice-covered regions were depressed by reason of the great weight of ice placed upon them, and that when the ice disappeared they rose again with extreme slowness, and may have eventually attained nearly their former level; but in most cases, I believe, some amount of permanent depression probably occurred.

The amount of depression would depend on two things, viz.:—

1. The weight of ice.
2. The elasticity or yielding nature of the area on which it lay.

The amount of ice that accumulated upon the land during the period of maximum glaciation is now admitted on all hands to have been very great. Whether we ask the geologists of Scandinavia, or of Switzerland, or of Great Britain, or of Canada, or of the United States, all of them will tell us that the thickness of the ice in these regions must be reckoned by thousands of feet.

Assuming the specific gravity of the ice to have been 875 compared with water as 1000, or in other words to have been seven-eighths of the weight of water,[1] then the weight of a mass of ice 1000 feet thick, would be 378 pounds to the square inch, or equal to fully 25 atmospheres, and would amount to 678,675,690 tons on every square mile. If the ice was 3000 feet thick, it would at this rate amount to over 2000 million tons on the square mile. If 4000 feet thick, it would give a pressure of a hundred atmospheres, or 1500 lbs. on the square inch.

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[1] A. Helland found the sp. grav. of the Greenland icebergs to be 886. See Quart. Journ. of the Geol. Soc. vol. xxxiii. p. 155, Feb. 1877.

Now we have every reason to believe that from 1000 to 3000 feet was quite a common thickness in many of the glaciated regions of Northern Europe. Some authorities indeed place it at a higher figure, while in America both Agassiz and Dana calculate that a far greater depth of ice existed. The latter thinks that on the Canadian watershed it must have been 11,000 feet thick (Manual of Geology, 2nd ed. p. 538), and on the northern border of New England he supposes it had a mean thickness of 6500 feet.

In some of the Fjords of Norway Mr. A. Helland puts it at 6000 feet.

But without insisting on these high figures, it is evident that a thickness of even 3000 feet of ice will give us a weight by no means despicable, a weight which would require a marvellous rigidity indeed in the earth beneath it to sustain such a load without yielding in some degree.

But no substance we are acquainted with is absolutely rigid; it always yields more or less to pressure, and when the pressure is removed it tends to resume its former position, and will do so more or less perfectly according to the elasticity of its nature. Some bodies are so elastic as to regain their original form completely, without suffering any permanent change; and physical authorities tell us that practically speaking almost every solid body may be considered perfectly elastic up to a certain point. That is to say, there is generally a limit of constraint from which it will recover when the strain is removed. But if the strain is carried beyond this limit, the body undergoes a permanent change in shape or size, and acquires what is technically called a *set* from which it does not recover.

Now, that the crust of the earth is flexible and elastic the phenomena of earthquakes sufficiently demonstrate. The surface heaves like the billows of the sea, sometimes causing trees to bend so as to touch the ground with their tops, or tossing up flagstones into the air so as to make them come down bottom upwards. Waves of elastic compression are transmitted many hundreds of miles from the seat of disturbance, as in the case of the great earthquake at Lisbon, when the water of lakes in Scotland rose and fell two feet in vertical height as the shock passed along. All this implies some amount of flexibility, which no doubt will vary a good deal according to the nature of the strata and materials of which the earth is composed. Geologists seem inclined to believe that whether the great internal mass of the earth be fluid or not, there are, at all events, great pools or lakes of melted matter here and there in the interior, at various depths below the surface; and if this be so, a region lying above an elastic cushion of this sort would be more likely to yield to pressure than where the substructure is more solid. A very small amount of yielding is all that is required, spread over so wide an extent as to be quite inappreciable to the eye when [illegible]ved in a section drawn on a true scale; and that the earth is so [illegible]utely rigid as to sustain with indifference the imposition of a [illegible]ht of ice thousands of feet thick over areas of almost continental dimensions seems to me very improbable indeed. It appears more likely that the position of the surface is in a state of delicate equilibrium, and that any considerable transference of pressure will cause a re-adjustment of levels. If upheavals and depressions of the land have not been caused by changes of pressure, it may be asked what is it they have been caused by? In volcanic eruptions even so slight a difference in pressure as the varying weight of the atmosphere has been thought to have some influence on the subterranean forces. The elasticity of the ground is so great indeed as to respond to very insignificant agencies. The rumbling of a waggon along the street, the galloping of a troop of horse, or even the measured tread of armed men, causes a vibration of the surface which is plainly felt.

If beneath that part of the surface which was affected by the heavy pressure of the ice there happened to be a quantity of lava in a fluid state, the result might be to cause an outburst of the lava to take place at some more distant point. This would relieve the tension and lead to a permanent depression of the ice-covered area. For example, in North America, the great fields of ice that lay on certain portions of that continent by their downward pressure may have occasioned some of those extensive eruptions which seem to have taken place in the region of California after the commencement of the Glacial Period.[1] The volcanic phenomena of Iceland in like manner may have been affected by similar causes. That there has been a considerable permanent depression of some of the most heavily glaciated regions since the commencement of the Glacial period I think there is much reason to believe. The features of the Fiord districts of Norway and the West Highlands of Scotland and of British Columbia, for example, seem to show this; for these coasts have all the appearance of depressed mountain lands, which have been cut and carved by streams and glaciers far beneath the present level of the sea. The glaciation of the United States also presents some singular features that seem to point to an elevation of the Canadian ridge between the lakes and Hudson's Bay much greater than now exists.

But in regard to the effect of pressure, time is an important element in the problem.

Bodies that seem absolutely rigid to pressure applied for a short space of time yield perceptibly to a force which is long continued. The effect may be so minute as to be quite imperceptible at first, yet when multiplied a sufficient number of times it will give us all that we require. And this is just the lesson that Geology has so often impressed upon us. Now in the case we are considering we can draw largely on the Bank of Time.

In regard to the pressure exerted by the ice, we must bear in mind that it probably continued for very many thousands of years. If we suppose that it caused a depression of only an inch in the year, this would give us a foot in 12 years, 100 feet in 1200 years and 500 feet in 6000 years; and this might be much more than we require, for allowing longer time far less than this might be enough. Now an inch in the year is less than a hair's breadth in the day.

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[1] See J. Le Conte, On the Old River Beds of California, in the American Journal of Science, for March, 1880.

The earth's diameter is about 7900 miles, which is equal to rather more than 500 million inches. Suppose then we had a pile of books consisting of a million volumes, each containing 1000 pages, a compression of an inch would be represented by the thickness of only a single leaf or $\frac{1}{500,000,000}$ part of the whole. Now for a depression of an inch we may allow at least a whole year and perhaps even five years. The action we invoke therefore does not seem to be an unreasonable or extravagant one.

The recovery of level after the ice disappeared would depend upon the elasticity of the materials beneath the depressed region. The rise would probably be very slow and gradual, like the depression, and in many cases the recovery of level would probably be incomplete. The unequal strength of the earth's crust and the irregular way in which it yields to pressure are exemplified by what we know about *faults*.

Faults are often of great magnitude, extending sometimes to many hundred feet and occasionally, it has been supposed, to even thousands of feet; and they show that the subterranean structure may be such as to give way very unequally to pressure. It has been thought that subterranean cavities exist which might allow a permanent amount of subsidence to be effected with comparative ease.

The general paucity of animal remains in the marine beds of the Glacial period would seem to indicate that the actual occupation of the surface by the sea-waters had not been very prolonged, for had it been so, we should expect to find remains of whales, seals, and fishes, far more abundantly than we do, and also great beds of sea shells.

Animal life swarms in many parts of the Arctic Ocean, and we can hardly suppose the sea to have occupied our coasts for thousands of years without leaving remains of marine life in a degree of plenty far beyond what we find in any of the Glacial-Marine beds of this country. During the commencement and earlier stages of the depression the submerged tracts which are now above water would probably be occupied by glacier-ice, and it would only be after the ice broke up and floated off that the sea would take its place, by which time the land would be on the rise again. The subsidence of the land no doubt contributed much to the dispersion of the ice by enabling it to float away and get melted in warmer water.

If the glacial conditions were simultaneous in the north and south hemispheres during the age of ice, there can be little doubt that the abstraction of so great a mass of water from the ocean, together with the contraction in bulk of the water owing to the colder temperature, would have very sensibly lowered the sea-level, as Mr. Alfred Tylor pointed out.[1] But owing to the want of proper data on which to calculate the total cubic contents of the sea, and of the supposed glaciers, it is difficult to form any good estimate of the change of level that would result from such a cause. If there was an ice-cap at both poles at the same time, the centre of the gravity of the earth would remain much as it is, and the cause of submergence invoked by Dr. Croll and M. Adhemar would not come into operation.

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[1] GEOL. MAG. 1872, pp. 392 and 485. Mr. Alfred Tylor calculated that a deposit of snow and ice 1500 feet thick over an area of land one-tenth of that of the sea, would reduce the level of the ocean 150 feet. He supposes a subsidence of [illegible] feet altogether.

(*To be concluded in our next Number.*)

## IV.—NOTES ON THE GEOLOGY OF THE COUNTRY AT THE BASE OF THE S.W. SLOPES OF THE URALS.

By W. H. TWELVETREES, F.G.S.

THE country at the base of and forming the south-western slope of the Urals has been little visited by geologists from Western Europe, and deserves more attention than it has received. Several years' residence in it form my excuse for recording a few notes thereon. The area I have travelled over extends from Samara on the Volga in the W. to Preobrajensky and Bieloretzky in the E., and from Orenburg in the S. to the town of Ufa in the N. The formations met with within these limits are the Silurian, Devonian, Carboniferous, Permian, and Jurassic. The three former are the crystalline rocks of the Urals, the western edge or front range being composed of Carboniferous grits and limestones. The foot hills are Lower Permian, made up of gypsum, red sandstones and marls, conglomerates, and different varieties of rather homogeneous, compact limestone. This division of the Permian, which only in places yields *Unios* or *Anodons* and plant-remains, gives way further west to the highly fossiliferous Magnesian Limestone, upon which repose the copper-bearing marls and sandstone of the great Permian steppe.

A journey due E. from Kargalinsk over the Lower Permian country to the Carboniferous mountain rocks showed the conglomerates and sandstones undulating in gentle flexures to within five miles of the front range, and then they dip to the W. The lowest of the Permians was a band of massive gypsum. Five miles further N. the same band was met with, and eighty miles still further to the N.W. the gypsum preserved the same relative position. The outlying conical Carboniferous Limestone hills at Sterlitamak in the Ufa government, which have burst through the Lower Permian rocks, bring the same gypsum up, which is to be seen at their eastern and southern bases. The band of gypsum first referred to lay on the W. side of the Ik, and the alluvium of the valley obscured any succeeding rocks. Those on the other side of the river were the grits and sandstones of the Carboniferous dipping E. towards the mountains. These were succeeded by the grey crystalline Carboniferous Limestone also dipping uniformly in the same direction. Here then the Permian and Carboniferous would appear to be unconformable. Further N.W., near Voskresensk, the Carboniferous Limestone dips W., and is succeeded by overlying sandstones and coaly flags with plant-remains thinly developed, and these, which are apparently here the uppermost members of that formation, are conformably overlain by Lower Permian sandstones and conglomerates with gypsum. A succession of marls of various colours, almost unfossiliferous limestones, pebble-beds and sandstones then occupy the country till the Magnesian Limestone is reached. I have repeatedly searched the lower limestones for fossils, but the only traces of anything are obscure tubular branching substances, which I could not with certainty identify as organic. Besides these, were faint markings which might be fucoidal. From the grits and mud-like shales of a copper mine at Darghina, fifteen miles S.W. of Voskresensk, I obtained several species of *Unio* and many ferns. With the identification of these I have only proceeded thus far:—

*Odontopteris Permiensis* (Brongn.)
*Cyatheites Schlotheimi*, var. *latifolius* (Göpp.)
*Callipteris* (Brongn.) sp.
*Neuropteris salicifolia* (Fischer).
*Neuropteris tenuifolia* (Sternb.)

The conglomerate of the Krasnaia Gora, W. of Voskresensk, which reposes on the compact limestone, contains many rolled fragments of the fossiliferous Carboniferous Limestone, which, in spite of the apparent conformity, would suggest a Post-Carboniferous movement taking place in Lower Permian times.

Near Voskresensk some of the conglomerates are cupriferous, but the pebbles render the ore intractable in the furnaces. The ore averages 4 to 5 per cent. fine copper. Experiments are being made with a view to gain the copper by the humid process, and have proved successful when conducted on a laboratory scale.

These lower rocks of the Permian form a very distinct division of the formation, and are, I suppose, the equivalent of the Rothliegende. I have not seen any vertebrate remains from this division.

The limestone with Zechstein fossils may be seen in the country to the W. of the Ufa and Orenburg post road, but is most fossiliferous in the Grebeni peaks near Orenburg. It forms two anticlinals near Jemangoolova, and is seen all through this part of the country to pass under the upper copper-bearing sandstones. The superior contact rock is generally a light-coloured or yellow sandstone. In the Kargalinsk district the limestone has a persistent character, and gives place definitively to the cupriferous sands.

The mines are small, but very numerous, and the few fossils found in this upper series are derived from the ore beds. It is to be regretted that many specimens are scattered all over the world, and are lost to science. I know an instance of a perfect reptilian jaw (I suspect of the rare genus *Rhopalodon*) having found its way to England in the possession of an agent at these mines, and on making inquiries I learn that it has been presented to a relative in Australia. These rocks consist of alternating sandstones and marls, with much irregular bedding, and are characterized by great want of constancy even in limited areas. This may be exemplified by the following sections of four mines in this field in descending order.[1]

*Ordinsky Mine.*—1. A few inches of black earth. 2. Eighteen feet of red clay. 3. Twenty feet of red sandstone and clay.

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[1] The sections were taken by a resident agent, Count dal Verme.

4. Seven feet of grey sandstone. 5. Two feet of grey marl and white sandstone, with poor copper ore. 6. Two feet of white sandstone with cupriferous beds. 7. Red marl.

*Troitsky Mine.*—1. Twenty-five feet red clay. 2. Forty feet of red sandstone and marl. 3. Six feet of brown sandstone. 4. Eight feet of yellow sandstone. 5. Ore bed four feet. 6. Yellow and grey sandstones.

*Vichy Nikolsky Mine.*—1. Twenty-five feet of red clay and marls. 2. Twelve feet of grey marl. 3. Ore bed three feet. 4. Yellow sandstone three feet. 5. Red marl.

*Droojeloobny Mine.*—1. Twenty feet red marl. 2. Three feet of yellow sandstone. 3. Ore bed three feet. 4. Yellow sandstone. 5. Red clay or marl.

All over this area there are no repetitions of the limestone. The Government of Orenburg affords a truly typical display of the Permian rocks. In the eastern part are the lower limestones and sandstones, in the central part is the band of Zechstein limestone, while the Kargalinsk area is occupied by the upper series of sands and marls.

The conglomerates of the lower division are more powerful than those of the upper, which are very thin and local. No gypsum has been observed in the Kargalinsk series. The homogeneous limestones so prevalent near the base of the system are here absent from the upper beds. The copper ore is more irregularly distributed in the lower beds than in the Kargalinsk steppe. A combination of these characters, apart from stratigraphical considerations, will generally enable a practised local observer to ascertain whether he is on Lower or Upper Permian ground, though of course there are localities which may fairly puzzle one. I should therefore be disposed to dissent from the Rev. A. Irving's view that the "limestones and dolomites of the Russian series are repeated over and over again through nearly its whole range."[1] In the Bielebee district, in addition to the supra-Zechstein marls and sandstones, intercalated marls to a small extent and thin developments of sandstones occur in the Zechstein Limestone, and that district (though not the intercalated marls) having yielded to Sir R. Murchison most of his Permian plants, was much emphasized by him, and has become a kind of typical ground for students of the Russian Permian, while I should rather insist on the rocks of the Orenburg government being taken as the type. The Zechstein Limestone of Bielebee is below the marls, sandstones, and grits containing bones of Saurians. That some data are needed for an appreciation of the correct age of the Kargalinsk cupriferous beds may be seen from the uncertain tone of Ludwig's treatise on the Dyas in Russia.[2] He says, "It is not clear from Murchison's description whether the cupriferous sand ores of Kargalinsk, in which silicified wood, impressions of plants, *Palæoniscus* and bones of Saurians have been found, belong to the Rothliegende or to the beds which at Nijni Troitsk [Bielebee district] overlie the Upper Zechstein." He comes to the conclusion[1] that the upper (fluviatile or lacustrine) group with *Uniones*, plants and Saurian bones, must for the present be placed somewhere between the Palæozoic and Mesozoic rocks, or equivalent to the Vogesen Sandstone of Subzbach (Lower Trias). This is just the point requiring settlement, and every scrap of information bearing upon it is valuable.

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[1] Geol. Mag. April, 1882, p. 161.

[2] Geinitz, Dyas, vol. i. p. 300.

To avoid confusion it may be mentioned that the present government of Ufa, in which the Bielebee district is situate, was formerly part of the government of Orenburg, and that the mines of Kargala or Kargalinsk, to which I have been referring, are not those of Kargala in the Bielebee district.

M. Möller believes that certain portions of the Permian field were deposited synchronously. I do not know to what extent he applies this theory; but when there are on this parallel such plain evidences of superposition, I cannot bring myself to believe that the three divisions of the system or any two of them were laid down at one and the same time.

A few miles S.E of the village of Jemangoolova, on the Orenburg-Ufa post road, and 20 miles east of the Voskresensky mines office on the Kargalinsk steppe, is the hill of Saragul, the base of which consists of the Upper Permian beds. The upper part of the hill is composed of a horizontal or nearly horizontal bed of Jurassic sandstone crowded with shells, according to Murchison, of the Oxfordian division, but in the opinion of Dr. Trautschold, who is *par excellence* the historian of the Russian Jura, characteristic of a superior horizon in the system.

In a subsequent communication I hope to furnish a list of the Mollusca found in this patch of Mesozoic rocks. Von Qualen asserted that he discovered chalk with fossils on the eastern side of this hill, but Mr. Rickard and I have more than once made a fruitless search for it. The nearest Jurassic strata are about 80 or 100 miles to the south, and the position of this isolated cap is suggestive of great denudation over the intervening area, which is occupied by the Permian beds.

Apart from points of local or special interest, the whole surface of the steppe from here to the Volga, with its comparatively loose materials arranged in more or less horizontal layers, opens up some questions of general importance. Is it possible that this immense plain was raised in its entirety to its present elevation by plutonic force? Were the organic remains now found in the beds of copper ore restricted to those sinuous channels, which may mark the courses of streams which during various changes of level flowed through land surfaces? Or were they originally scattered also through the red rocks which are now destitute of them? Mr. Rickard has noted that the latter rocks lose their colour and much of their iron when in contact with the ore beds. The theory which will explain the formation of the copper ore and the preservation of the organic remains in it will have also to account for the sterility of the red sands.

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[1] *Op cit.* p. 304.

## V.—FURTHER REMARKS ON THE ORIGIN OF THE LOESS.

### By SEARLES V. WOOD, F.G.S.

IN a previous communication to this MAGAZINE I suggested that the Loess originated from the thawing and refrigeration, during the major and minor glaciations, of the upper layer of the soil, which, where it was unprotected by land ice, was permanently frozen to a great depth; such layer having a sliding motion which caused the material to accumulate in the hollows, and so expose continually to this action over the rest of the surface, fresh subsoil which had been previously permanently frozen. I now supplement this by a particular examination of the way in which such process appears to me to have acted in originating that part of the Loess which is represented by the "Limon," or brickearth, of Picardy.

With this "limon" I have no personal acquaintance, but it has been made the subject of a very careful and minute description by M. de Mercey, in the "Bulletin Mensuel" of the Linnean Society of the North of France, for the years 1874–5; and from such description the facts detailed below are exclusively derived.

M. de Mercey first glances at the different views taken by geologists as to this formation, viz., that of M. Elie de Beaumont, who referred the part of it which occupies the plateaux, to the "Ancient alluvia of Bresse, of the Pliocene formation," and the part which occupies the valley slopes to the "modern superficial deposits;" that of M. D'Archiac, who regarded the limon on the plateaux and on the valley slopes as "one and the same deposit, termed by him ancient alluvium posterior to the rolled flints with *Elephas primigenius*, and forming the last term of the Quaternary series;" and that of Mr. Prestwich, who regarded "the limon of the slopes as due to successive inundations at the different levels of the gravels, and its age, like that of the gravels, proportionately more recent as its level was lower, and, with the gravel it covered, as being connected with the excavation of the valleys, but distinct from the limon on the plateaux, the reconstruction of which had furnished part of the material for that on the slopes, and the formation of which dated back to the Pliocene epoch."

He then describes minutely the character and description of this limon, insisting himself that it is all of one mode of formation, and of one period, viz., "the last term of the Quaternary series," (whatever that may mean,) "covering the ancient alluvia" (*i.e.* the gravels of the Somme valley,) "and all other deposits except the modern." He adds that though of small thickness on the valley slopes, and low elevations, it is sometimes upwards of ten mètres thick on the higher parts of the plateaux, that it is yellowish in colour, and "*biéfeux*" with flint fragments towards its base. Everywhere it is unstratified.

The chief fact which strikes us, he says, is the particular breaking up of materials derived from the formation on which the limon rests, and their dissemination in its base. This subjacent formation in the neighbourhood of Amiens is the chalk with flints, and angular fragments ("*éclats*") of these flints are scattered through the limon which occupies the slopes, and is termed "limon biéfeux." Near Amiens, he says, the limon which covers the valley slopes is generally much thinner than that at the foot of the slopes, or on the plateaux, and the pits on the latter "always encounter beneath several mètres of purer limon, the limon biéfeux with flint fragments covering either the biéf à silex or the chalk. Upon the slopes of the hills, or at their feet, the brickpit sections always show this biéfeux bed with éclats of flint in contact with the chalk, or with the gravels underlying the limon." This "biéfeuse" base of the limon, he adds, "ravines" more or less deeply the subjacent deposits.

Next he observes that the limon biéfeux contains along with the flint fragments some entire flints derived from the formation on which it reposes, which if extracted with care are found to be split in all directions, but have their fragments held together by a feeble cement of the limon; the surfaces of these fragments thus held being whitened, and rendered porous and opaque. This, he says, occurs equally whether the flints are obtained from the base of the limon, where this occupies the surface, or from beneath a thickness of several mètres of the limon, where they are protected by it from all present influence of atmospheric conditions; and having submitted to an artificial refrigeration, equal to the greatest cold of our present winters, flints steeped for some time in water without producing by it any change in their condition, he infers that recourse must be had to the rigour of polar winters and to "a glacial pressure" to explain their splintering.

M. de Mercey then describes the materials into which specimens of this limon when dissolved in water, thoroughly shaken, and allowed to precipitate, became resolved when examined under the microscope. This examination showed the limon to be nearly all made up of "grains of quartzose sand reduced to an impalpable tenuity." The first precipitation from the solution (and which was almost immediate), represented about $\frac{7}{10}$ths of the limon assayed; and was composed of transparent grains of quartz of the average dimension of $\frac{1}{20}$th of a millimètre, with which were associated some other grains appearing to belong to different substances, and notably to oxide and sulphate of iron. The next precipitation from the solution represented about another $\frac{2}{10}$ths of the limon assayed; and was composed of grains of quartz, mostly transparent, averaging about $\frac{1}{50}$th of a millimètre; while the remaining $\frac{1}{10}$th, which remained a long time in suspension, was composed of grains of quartz averaging $\frac{1}{300}$th of a millimètre. This showed that the limon was composed almost entirely of silex, a feeble proportion only of other substances, alumina, lime, oxide of iron, etc., being present; and led M. de Mercey to the conclusion that it originated in an impalpable powdering (levigation) of the flints, and resulted from a reconstruction of the "biéf à silex," which at the time of the formation of the limon constituted the superficial soil of nearly all the region, except that occupied by the ancient alluvia, or by the chalk exposed in the excavation of the valleys. A washing of this red "biéf" showed him that though inappropriately called clay, it, like the limon, is composed essentially of quartz grains, with a proportion of peroxide of iron enveloping these, and giving colour to the mass, such grains being of dimensions similar to those found to make up the limon, but associated with a preponderating number of larger grains.

From this investigation M. de Mercey comes to the conclusion that the limon, thus originating from the levigation of the flint, had flowed as mud from a sheet of land-ice similar to that of Greenland, which moved over Picardy; and therefore he designates it "*Limon glaciaire*;" but herein in my opinion lies his error, for we know by the Chalky clay what the morainic mud was which resulted from land-ice moving over a chalk country. This, where the Jurassic clays as well as the chalk contributed to its constitution, is clay more or less full of rolled chalk, and of flints (besides stones from the old conglomerates,) which are large and subangular, the splinters or angular fragments (éclats) abounding in the Picardy limon, and in the formation which corresponds to it in the South and South-east of England, being altogether absent; and where, as on the flank of the Lincolnshire Wold, the chalk alone has, save to a slight extent, furnished the material, it is so made up of the chalk itself, reconstructed, as to be quite white, and burnt for lime; whereas this Picardy limon is, according to M. de Mercey, nearly destitute of lime, and formed entirely of flint from the chalk beneath it, disintegrated.

The true origin of the limon thus described seems to me to receive its explanation in the process referred to in my previous communication, viz. the annual thawing and refreezing of the upper layer of the permanently frozen land surface, which everywhere, save beneath the land-ice, was subjected to the intense cold of an arctic winter. We lack, it is true, what would be important towards a complete demonstration, experimental evidence of the effect on flint of cold like that of a Siberian winter—say from 40° to 70° below zero of Fahr., but it is evident that some cause not now in operation here has ruptured, in the way described, the flint of the Picardy limon, and the flint of which angular fragments are distributed through the corresponding formation of the south and south-east of England, as well as the angular fragments of stone distributed through this in parts, such as Lincolnshire, where it rests on limestone. M. de Mercey assigns the biéf à silex as the source of all the siliceous grains and flint éclats of which the limon is made up, but though, from atmospheric agency during the terrestrial interval anterior to the major glaciation, the land surface that remained above the line of the submergence which accompanied this glaciation in Picardy had probably become covered with flints, and from similar agency during the interval between the major and minor glaciations (where, save to the extent that the sea reached up the valleys there, Picardy was all land, and the *Cyrena* gravel of the Somme overlain by this limon accumulated), the surface of the lower elevations, which had been denuded of the gravel of the great submergence by the waves during the rise from this submergence, and so become bare chalk, may have to some extent become covered with flints, yet I consider the red biéf à silex, the brown limon biéfieux, and the yellow purer limon as all one in their mode of origin, and the process giving rise to them to have been thus, viz.: The subsoil having become permanently frozen to a considerable depth, and all vertical percolation thus arrested, the annual alternation of frost and thaw in the upper layer of this shattered the flints there, and so produced the angular fragments of flint (éclats) and grains of silex, of which the "biéf à silex" is made up. Upon this material, as well as upon the chalk with flints beneath (as, by the sliding of the material, it became exposed to the alternation of thaw and frost), and upon the resulting limon as well, the shattering agency continued to operate; and by this the flint became eventually reduced to the state of fragments, varying from the "éclats" to the minutest grains, of which the limon is made up. Having only the two or three feet of thawing surface layer to saturate, the water resulting from the thawing of the snow and the rain during summer took up by degrees all the chalk in this layer, and filtering through the mass of silex grains and éclats escaped with it, spring-wise, along the surface of the permanently frozen ground beneath ("ravining" this surface as it did so); so that the calcareous part of the parent soil, the chalk, was removed, and the siliceous part left; while the slide of this surface layer during a long period caused the resulting material to accumulate thickly in places favourable to such accumulation.

Thus, it seems to me, the lower portion of the limon, which was formed when the chalk itself was the main source, should, as M. de Mercey says it does, contain the larger fragments most abundantly, and have at its base a material, the "biéf à silex," formed principally of the coarser grains, and inclosing flints shattered into éclats, but held together by the limon in the form of an entire flint; while, where the accumulation is thick, the upper portion of it should be, as he says it is, more free from éclats by reason of the surface from which this slid, and on which the process was now operating, having become to a great extent limon instead of chalk.

Where, as upon the higher (*i.e.* the *un*submerged) parts of the plateaux, this process went on during the long duration of the major glaciation, and was renewed during the (probably much shorter) duration of the minor, there has thus accumulated, according to M. de Mercey, limon wholly made up of disintegrated flint, which in places is 30 feet and more in thickness. The valleys having been below the sea during the major glaciation, the limon upon, and at the foot of their slopes is that of the minor glaciation only, which occurred when England, having for the most part recovered from the great submergence of the major glaciation, and again undergone the small depression and limited submergence which accompanied the *Cyrena* formation, was recovering from this also, and become nearly all land. It is therefore thin on these slopes, and over the *Cyrena* gravel of the Somme Valley, which occupies those slopes; though in hollows at their feet, and in the cavity afforded by the sea cliff of this time, which is exposed at Sangatte, it has accumulated more thickly.

Iow far the "clay with flints," which covers and conceals large as of chalk in the southern half of England, corresponds in its ieral constituents, and the arrangement of these, with the Picardy on, I am unable to say, being now physically unable to examine but in the memoir of the Geological Survey for Sheet 13 it is :ed to be met with only on the Upper Chalk, *i.e.* the chalk with ts; and it is this clay formation which, judging from the notes ;raved on the Survey Maps, wraps all those higher chalk elevations, 'ond the limit to which the land ice reached, that from their ıstituting areas higher than the line up to which the submergence the major glaciation is shown by the evidence of gravel beds to 're extended, or elevations so little below this line that they ame land before that glaciation passed away, that I have referred :he action in question during the major glaciation.

[he material which in England has, in my view, originated from ı action during the minor glaciation only, is in the south-east of gland represented by brick-earth, which, in the neighbourhood the Upper Chalk, is, like the Picardy limon, full of angular ;ments of flint. This, travelling from the chalk of the South wns, has "ravined"[1] and overspread the shingly sands with rine mollusca (all of living British species), occupying the area ween those Downs and the British Channel—sands which I ard as coeval with the *Cyrena* formation of the Thames Valley, ich, in the parts of it (such as the London Road pit at Ilford) t were above the river level of the time, is overlain by the responding atmospheric material of this glaciation, but in the ts of it that were below this level is covered with the river vel of the same glaciation, as at the Uphall Field, Ilford.

n other places, such as the limestone districts of South Lincolnre, which were buried under the land ice of the major glaciation, l the medium and lower elevations of the south-west of England, ich, covered by the great submergence, but not reached by the land of the major glaciation, did not become land until that glaciation l passed away, the material thus originating during the minor is loam with angular fragments which caps the Lincolnshire lime1e, the loam with Mammalian remains which wraps the Jurassic s of Wilts and Somerset, and the intrusive cave-earth generally :he South-west of England. These forms of it vary according to character of the parent formation upon which the process has rated; and it is the same material which, under one or other of se guises, buries the cliffs that skirted the British Channel coast he time of the incidence of the minor glaciation, and of which ions have occurred at Brighton, Isle of Wight Foreland, Portland, Sili Bay, Glamorganshire.

n the North of England, as far as the land ice supplied moraine, formation contemporaneous with this material of the minor glaciation is the Hessle Clay of the north-east, and the Upper Clay of the north-west; the former being wholly of terrestrial, but the latter at its lower elevations of submarine accumulation, and at its higher of terrestrial.

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[1] This brick-earth with angular fragments of flint is shown by Prof. Prestwich .G.S. vol. xv. p. 216) to overlie and "ravine" these sands in the sections of them h he gives from Avisford, just as M. de Mercey describes the base of the limon ravine" the subjacent deposits in Picardy.

The interesting deposit described by Professor Prestwich in the Quart. Journ. of the Geol. Soc. for May, 1882, as occupying hollows in the Lower Chalk plain near Chilton, is, though derived from the higher plain of Upper Chalk near by (and which, according to the Survey Map, is covered with the "clay with flints"), I think so far posterior, that it originated from the flooding of the land by excessive precipitation as the minor glaciation passed away, which, in the concluding part of my memoir "On the Newer Pliocene Period in England," I have assigned as the cause of the thin bed of flattened fragments of stone which, in South Lincolnshire, not only caps the loam with angular fragments that originated in the process of annual thaw and refreezing, but spreads also over gravel and sand not overlain by that loam; for though this Chilton accumulation contains, according to Professor Prestwich, angular flint fragments abundantly, there also enters into its composition much reconstructed chalk, as well as a bed of laminated clay intercalated in a roughly stratified portion of the deposit.

Whatever may be the case with the Loëss in China, it is clear that the material here discussed by me has not originated from dust clouds; for the dust of a chalk country could hardly give rise to a material in which, according to M. de Mercey, there is no appreciable quantity of lime, or the wind rupture the flints, and scatter their fragments through the mass in the way described. And in reference to the dust theory generally, one is tempted to ask why, if dust gives rise, as is asserted, to a vast formation extending over immense areas, and accumulating in places to the thickness of 1500 feet, in which are preserved the skeletons of the animals dying on the land, those regions which have been land from a remote geological age do not present us with beds of this kind, containing the remains of these animals which have lived during the long interval between that age and the present, and thus perfect that Palæontological record which as yet is so imperfect?

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## VI.—Traces of a Great Post-Glacial Flood.

### 3. The Evidence of the Valley Terraces.

By H. H. Howorth, F.S.A.

(*Continued from p.* 311.)

We must now turn to the theories which make these terraces to be deposited by the rivers when so charged with water that the whole valleys, from their solid foundations up to a height of at least 80 feet, were filled with water. These theories postulate no gigantic denudations extending over limitless ages, but accept the valley terraces as fluviatile deposits left along their own banks by the rivers when, by means of exceptional causes, they were, at one time, so flooded, that they actually reached the upper level terraces which in fact represent their old banks when so flooded. Two causes for such abnormal floods have been assigned. Mr. Tylor postulates a Pluvial period, characterized by most exceptional rainfall; while Mr. Belt urges that these floods were caused by the pounding back of the European rivers, and the consequent formation of a European lake by a great Atlantic glacier.

Both these theories, like those which have been already examined, in claiming the rivers or a lake, either in their normal or abnormal conditions, as the depositors of the terraces, fail to meet the supreme difficulty we have pointed out before, that the deposits are not fluviatile or lacustrine at all. Their contents prove them to be other than river or lake deposits, either of normal rivers or lakes, or rivers or lakes expanded by abnormal floods. There is another reason equally potent. If these deposits were the result of successive river floods, or of river floods distributed over a long period, we should assuredly have the deposits arranged in layers, marking the secular variations of the water, such as we find in all river-warp and similar deposits. Here, however, we have no such facts, but the gravels, sands, and loam are deposited according to the laws of gravity, as they would be deposited by one supreme effort.

That the gravels were deposited where they are now found by water, and water in rapid motion, is inevitable; that this water must have filled up the valleys at least to the height of the upper layer of gravel is equally inevitable; but that this water should have been merely the present rivers, swollen by abnormal rainfall, seems assuredly incredible. With the present water-shed and drainage we cannot conceive such floods, caused merely by rains, without postulating a quite transcendental meteorology.

Mr. Tylor does not in fact argue that such a rainfall as he requires is possible with the climatic conditions now in vogue, but he boldly accepts the position that climatic conditions were at that time entirely different. He attributes the enormous rainfall of his Pluvial period to "the sun's influence, which induced a much greater amount of sunshine in summer and a corresponding diminution in winter;" but where have we any warrant for such an hypothesis? In regard to the meteorological conditions of the climate when the gravels and river terraces were laid down, we have the best of all barometers ready to our hands in the abundant remains of plants and animals, which not only mark the mean temperature, but limit also the extremes; and this barometer, with manifold readings all concurring in one conclusion, is surely conclusive that the climatic conditions of this period were such as prevail now in our temperate latitudes, and quite inconsistent with those required by the hypothesis of Mr. Tylor, and which are necessary if we are to secure such an abnormal rainfall as 300 inches annually in England.

A fall of rain in temperate latitudes on this gigantic scale is assuredly a contingency verging on the impossible, and especially when we are told that such a rainfall was not a mere exceptional feature, but characterized a whole geological period, to which Mr. Tylor has given the name of the Pluvial period.

Mr. Tylor points to the tremendous rainfall that occasionally occurs in the plains of Scinde, to which might be added Brazil, Central America, etc., etc. All this is perfectly true, but in all these cases the meteorological conditions are entirely different. To import "the Rainy Season" or the torrential rains of the Tropics into our temperate climate, and into our part of the earth's surface, is a postulate which demands certainly very rigid proof. That the warm winds heavily charged with moisture moving westward from the Mid-Atlantic should be stopped by the high barriers of the Andes, and the similar warm winds from the Indian Ocean should be similarly stopped by the Himalayas, and in either case should be forced to discharge their contents in vast sheets of rain upon the intervening plains, is not only natural but is a necessary conclusion. There are no such conditions available here. We cannot suppose that the North Atlantic was ever the nursery of such heavily charged warm winds as the Mid-Atlantic, nor have we impassable mountain barriers in Europe to force these winds to discharge their contents in any way comparable to the rains of the Tropics. But even if we granted the conditions of the tropics as possible, we are still very far from having secured a sufficient amount of water to fill up the river valleys of Western Europe, in some cases to the brim, and in most to a height of several hundred feet. Mr. Prestwich states the conditions with his usual force. "The greatest flood of the Seine on record," he says, "is that of the year 1658, when it rose to a height of 29 feet. Even in this case a flood of nearly sixty times that magnitude would be required merely to fill the valley to the level of the high-level gravels, without taking into consideration the more rapid discharge; but neither in this nor in the other cases of modern times are we aware of an increase in the volume of water during floods in these regions to many times the ordinary mean average, whereas we see that in a case such as is presented at Amiens a flood having a volume five hundred times that mean would be required to reach the beds of St. Acheul" (Philosophical Transactions, 1864, p. 266). But, granting that the meteorological conditions are admissible, which we altogether question, we have still greater difficulties behind. Mr. Tylor urges repeatedly, and it is in fact the burden of his argument, that the enormous rainfall he postulates (many times greater than that prevailing now) would greatly increase the velocity of the streams and rivers, and thus explain the great erosions which, he contends, are witnessed by the deposits in dispute. "Ancient rivers," he says, "may have had many hundred times as much destructive effect on the surface of the earth, for erosive force increases in the fourth power of the velocity, and may have eroded the surface of the earth as much in former times in one year as they now do in 1000, in cases where rocks were made to slide on clay by excessive supply of percolated water" (Geol. Mag. 1875, Decade II. Vol. II. p. 459). In all this we seem to be on the track of most misleading analogies, and to be led away by a postulate which Mr. Tylor quotes more than once, namely, that the water in a river has a uniform motion. This is true in one sense, but it is very misleading in another. The most elementary knowledge of a fast river obtained in trying to force a boat against the stream is enough to show that, if we take a vertical section of it, at any given point, the water in all parts of that section is not flowing with uniform velocity. The current is very rapid in the middle of the river, but dies away as we near the banks, and in many cases is barely perceptible there. The drag of the banks is proverbial, and greatly assists navigation up stream; but the drag of the bank is really the drag of the river bed, and, as a matter of fact, a swift river is a swift current flowing through a cushion of water moving much more slowly. This is a well-accepted fact in hydrostatics, and has been confirmed by numerous careful experiments. In the case of deep rivers the cushion probably moves hardly at all, just as the Gulf Stream is a more or less rapid current of warm water flowing in a cushion of much colder and much more quiescent water. It is this property of rivers which in my view probably explains how in the case of the Neva, the Volga and other rivers the freezing takes place first at the bottom, whence detached plates of ice rise to the surface and get united together, forming a natural bridge over a rapidly flowing current. The water in rapid motion would probably never freeze, if that which is much more quiescent near the bottom, which, therefore, freezes much more slowly, did not furnish it with a constant stream of materials for making itself an ice bridge. This has probably been suggested before, although I do not remember to have seen it. It is only mentioned here by the way. The real burden of my argument is that we must not suppose that, because a river is flowing with a full current in mid-stream, therefore it is denuding its banks and channel in a corresponding fashion. It would seem that large rivers do hardly any work in denuding the land, *except in their head streams.* It is in these that the work of grinding down and of denudation takes place, and the main stream does little more than bear along the mud, etc., in suspension which has been poured into it by its tributaries. All the great rivers known to me are, as regards their main channel, conservative and recuperative, and not destructive.

While such a rainfall as we have been discussing would not in my view increase the denuding powers of the rivers, it ought undoubtedly to have had a very potent effect in scouring the general surface of the land. It would assuredly have washed the high plateaux clean of their mantle of fine loam, and would have swept it away into the rivers, and thence into the North Sea. It might have left the larger blocks of stone there, but the fine loam would certainly have gone; but this is just the reverse of what we in fact find. As a matter of fact, the heavy debris is all in the valleys, while the uplands are mantled and covered with fine loam. Again, such a rainfall would no doubt have carved enormous ravines and rents in the contour of the valleys at rapid intervals, when the immense mass of water falling on the plateaux made itself discharging channels into the main river, thus breaking the continuity

not only of the solid skeleton of the valley, but even
terraces. No such series of ravines and breaks in
forthcoming however; but the latter run continuou
flanks of the valleys. Again, how could the lateral
principal valleys be charged with these deposits up
heads, as we actually find them, if the flow of these
predicated Pluvial period was so enormous, and at
continuously seaward? These would surely have
clean. How, again, could the terraces in such a case
materials sifted in the way we have mentioned?
makes even greater demands upon our credulity. E
has reiterated the opinion again quite recently in the
MAGAZINE, that during the Pluvial period the rate of d
nine inches per annum. Nine inches of solid strata
year, when we have only to go to North Wales. or
Scandinavia, to see numerous faces of rock with the f
by the ice in the Glacial period still sharp, alth
to continuous subaerial denudation for unknown
thence to gauge the real effects of rain and snow
agencies. Even if we could realize such stupendou
such causes, and if we could trace whither the deb
scouring has gone to, we should still have to face a
difficulty. Mr. Tylor does not deny that during his
the land was occupied by a teeming life both Botanica
cal, the remains of which so abound in the deposit
cussing, but how was this life possible? How, with su
down of the surface, was it possible for plants, eithe
and grasses upon which the land-shells fed, or the for
Mammoth lived, to grow at all? How could the cla
which Saporta and others have furnished us lists, hav
such conditions? How, again, could the animals do so?
Reade may well say that no mould could possibly for
circumstances except, perhaps, in deltas, as it would b
hundred times as fast as made. Whichever way
theory of a great Pluvial period, we are met by incorr
ties and contradictions, and we cannot avoid the conclu
not based on inductive evidence, for it will not expl
but is rather another example of the danger of the Ded
in science.

If we turn to the alternative hypothesis of Mr. Belt
better position. His theory certainly has the merit of

It is fair to quote it in his own words. He urge
height of the Glacial period, the bed of the Atlantic w
ice flowing from the north-west, from the direction
reaching from the coast of Europe either at Brest
point further south, and damming back the whole of t
Northern Europe into an immense lake of fresh water
greatest extension, reached to a height of at least 1200
present level of the sea. This lake was gradually low
hundreds of feet, probably by the deepening of a cha

and then suddenly and completely drained by the breaking away of the ice dam, causing an enormous flood or debacle" (Journ. Geol. Soc. xxxii. p. 84). In order to complete the boundaries of his lake, Mr. Belt elsewhere postulates that Behrings Straits was occupied by another ice belt, while the communication between the Mediterranean and the Black Sea was not then cut, and he urges that by the gorging of the rivers the waters rose all over Northern Asia and Europe, thus drowning the big Mammals, and when the ice barrier broke, the European lake discharged itself in a torrential fashion, and thus distributed the loose surface deposits of Europe as we now find them. This is assuredly a very bold hypothesis. If we try to realize the conditions of climate that would be necessary before the Bay of Biscay could be gorged with ice, or before ice on any great scale could exist in the sea in the latitude of the Pyrenees, while a temperate climate existed on the land, we shall measure some of the difficulties of such a theory. How could Hippopotami and Fig-trees exist in Northern France with such a mass of ice close by, that the sea must have had a temperature like that of the Palæocrystic sea? The short European rivers would, with such conditions, be permanently frozen, as would the waters of a European lake, formed by their being pounded back. Rain falling on the frozen ground would itself immediately freeze. To introduce the present conditions of Siberia into Western Europe when the Mammoth lived here, would be a trial to our faith; but to introduce those of Smith's Sound, and yet to make them coincident with a teeming animal and vegetable life, and a mass of liquid unfrozen fresh water, is indeed beyond all our powers of imagination.

We can no more credit Mr. Belt's explanation of the cause which distributed the valley terraces than we can one of Swift's imaginative tales. Such a theory is, as we think, at issue with the evidence, especially the evidence of climate furnished by the animal and vegetable remains. It also involves the creation of a lake so deep and vast in extent (for it must have reached to the level of the higher European plateaux where the fine loams are spread out), that we have no parallels with which to compare it, and it involves such a lake remaining unfrozen, although composed of fresh water, while the salt water of the Atlantic was gorged with ice several hundred feet thick, and discharging itself along lines, such as the trough of the English Channel, where, so far as we know, there are no appreciable traces of the great masses of *debris* there ought to be. Such a flood would sweep the land of the greater part of its soft mantle, while the flood required by the facts is one that spread such a mantle over the higher ground and thrust it into the heads of the lateral valleys, as we find it there.

But apart from this altogether, Mr. Belt's ice dam is a barrier apparently incompetent to prevent such a vast lake from draining unless it was of an entirely different nature to ice dams elsewhere. As Prof. J. D. Dana says, "There is no such damming as far as is known, about Greenland, the subglacial streams being large and flowing freely to the sea; and hence the practicability of damming the freshwaters in the way supposed may be doubted." (Silliman's Journal, 3rd ser. vol. 13, p. 384).

It seems to me most clear, in fact, that the fluviatile or lacustrine theories, whatever modification of it is appealed to, and under whatever conditions, as applied to the valley terraces, breaks down at every point. Where, then, are we to find an adequate explanation? It is clear that such an explanation must postulate some physical cause of an abnormally potent nature, which is not in operation at present. We cannot doubt that water was the means by which the materials of the terraces were, in many cases, sifted and redeposited. We cannot doubt, therefore, that this water must have reached to at least the level of the upper terraces. These seem inevitable factors. If so, are we not justified in having recourse to the same overwhelming cause which we have quoted so often in these papers—a vast and sudden rush of waters operating on a large scale? Assuredly such a flood would admirably explain the facts. It is perfectly consistent with the valley terraces being composed, as we find them, of subaerial materials, and containing no fluviatile shells, etc., and with their having been subsequently rearranged and transported, "remaniés," as the French call it. It is consistent with these deposits being found in continuous sheets in certain places, continuous too with the loams covering the high plateaux, and distributed independently of the drainage of the country. It explains how these deposits should occur in the lateral valleys up to their very heads. It explains the occurrence of the skeleton of the Rhinoceros described by M. Baillon at Menchecourt with its leg a little distance away, as if wrenched off by a violent blow, as we described in a former paper, just as the same kind of flood explains, as we have tried to show, the similar entombments in Siberia and in the Loess. It explains the occurrence of mixed bands with sea shells occurring with the subaerial loams and gravels we are discussing, at points near the sea, as at Menchecourt. The course of the great wave of waters having, no doubt, been largely up the rivers, and having, therefore, not only washed the loose materials up into the heads of the lateral valleys, but also mixed with the surface deposits at the outlets of the main valleys products of the sea with those of the land.

It explains the presence in the terraces of the Somme of masses of grey wether sandstone, several feet long, having generally their edges unworn, and, as Lyell says, when spherical, owing their shape to an original concretionary structure, and not to trituration in a river bed. These grey wethers are accompanied by broken chalk of every size from a fine powder up to fragments as large as a man's head. "Many of these fragments," says Dr. Andrews, "though soft enough to write with upon a blackboard, have preserved with absolute perfection the sharp angles and edges which they had at the time they were broken from the Cretaceous strata. It does not seem possible," he adds, that "they could have been rolled a hundred feet in the bed of a stream without losing their sharpness" (*op. cit.* 183). Ice has been the easy refuge for those who have needed a potent transporting agency to explain these blocks of stone and chalk; but independently of ice on this scale being quite inconsistent with the whole life-surroundings, zoological and botanical, of the period with which we are dealing, we cannot understand how it is to explain the existence of unweathered sandstone blocks, etc. If the condition of these masses and of the soft lumps of chalk is inconsistent with their having been rolled in a river, *a fortiori* is it inconsistent with their having been at the mercy of such a triturating element as ice, which it is the fashion now to bring in like the giant in children's toy-books, to solve every intractable riddle? The boulders which form moraines, which characterize the Boulder-clay, and which are found wherever we have unmistakable ice-action, bear a very different facies. The same conclusion seems to follow from the fact that among these blocks are never found fragments of rock foreign to the valley of the Somme, no erratics which have been brought from another hydrographical basin (Antiquity of Man, p. 182). The removal of these unworn blocks, and the accompanying pieces of friable chalk, from the adjoining plateaux whence they have been derived, it seems to me, must inevitably be assigned, not to ice, but to a great wave of transporting water. The same agent, lastly, accounts for the contorted and twisted, ploughed-up and disturbed beds, of which such excellent sections have been published by the Nestor of these inquiries, to whom we are all under such immense obligations, Mr. Prestwich, notably one on page 299 of his Memoir in the Phil. Trans. 1861, and by others. It explains, lastly, the sorting of the materials in the terraces, the heavier gravels below, and above them the covering of sands and pure loam.

It seems to me that every way we look at the problem as illustrated by the valley terraces, we must face one conclusion if we are to adequately explain the facts, namely, that of a widespread flood. Although I cannot for a moment believe in Mr. Tylor's Pluvial period, I must endorse the sentence in which he says "that we ought to judge of the height of a flood by means of the *debris* it has left, and not by any theoretical notions of our own" (*op. cit.* p. 124).

Again, excepting always the use of the word 'river,' and replacing it by the neutral word 'floods,' Mr. Geikie's words in the following sentence seem to be most just as describing the deposits in question. He says, "The rivers of the Pleistocene period often assumed a torrential character. . . . . Their torrential character is shown by the coarseness of much of the gravel, the flints being often very little rolled—by the absence of mud sediment, and by the confused and irregular disposition of the bedding—all bespeaking the action of tumultuous waters that hurried along promiscuous heaps of stones and scattered them in confusion over the slopes and bottoms of the valleys, while the finer sediments were swept away in suspension. When the water of the flooded river was in less commotion, the finer sediment held in suspension would be deposited, and this, as Professor Prestwich points out, has doubtless been the origin of many of the so-called Brick-earths and Loess of such valleys as the Thames, the Somme, the Seine and their tributaries. They are simply the flood loams laid down by the same river that deposited the valley gravels" (Prehistoric Europe, p. 130). Again, he says, "The size of the stones and the quantity of the material constituting what are called high and low level gravels sufficiently indicate the great transporting power of the Pleistocene rivers (say 'floods'—H. H. H.), while the Brick-earths with their delicate land shells covering all the gravels, and running up the valley slopes so as to cap the summits of hills far above the level reached by the highest river gravels, proves the former existence of floods, as Professor Prestwich has pointed out, of extraordinary magnitude" (*id.* p. 132-3).

I will conclude with a sentence from a paper of Mr. Flower, which sums up my own view admirably. He says of the forces which spread the surface deposits over our valleys, "We know nothing of them, except from their results; but whatever they may have been, it seems quite certain they are not ascribable to fluviatile agency, and I am therefore disposed, with the French geologists, to attribute them to some powerful cataclysmal action, perhaps of short duration, and several times repeated."

In the next paper I shall consider the evidence of the angular drift of the South of England and North of France.

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## VII.—SUPPLEMENT TO A CHAPTER IN THE HISTORY OF METEORITES.

By WALTER FLIGHT, D.Sc., F.G.S.

(*Continued from p.* 362.)

### Supposed Organic Remains in Meteorites, 1880–1882.

At the end of the year 1880, Dr. O. Hahn, of Reutlingen, a lawyer by calling, published a big work entitled *Die Meteoriten* (*Chondrite*) *und ihre Organismen mit* 32 *Tafeln photographischer Abbildungen* (1880, Tubingen: H. Laupp), by which he claimed to have shown the presence in meteoric rocks of sponges, corals, and crinoids. A statement of his views was read before a meeting of the Geological Society the same summer. Early this year Dr. D. F. Weinland published a paper in support of these views, *Ueber die in Meteoriten entdeckten Thierreste.* Illustrated with two woodcuts (1882, Esslingen: G. Fröhner). The question was thoroughly gone into in a scientific way by Prof. Carl Vogt, of Geneva, and the conclusions at which he arrived are contained in a paper entitled *Les prétendus Organismes des Météorites*, published 1882, Genève: H. Georg. It is shown that Dr. Hahn had no foundation for his conclusions; that all the pretended organic structures are purely inorganic; and that in no single case do they present the microscopic structure of the organisms for which they have been mistaken—such as crinoids, corals, and sponges. See also Dr. Laurence Smith on the subject in the *Amer. Jour. Sc.* 1882, February, 156.

### Specimens of Supposed Meteoric Dust which fell in the South of Europe and Algiers, between the end of March and beginning of May, 1880.[1]

In Sicily showers of supposed meteoric dust are often observed, sometimes with, sometimes without rain. During such a shower the air becomes murky and of a reddish-yellow colour, and the barometer falls rapidly. A heavy rain leaves a characteristic yellowish-red residue. Dust fell on the night of March 29, 1880, at Catania, containing, in addition to the ordinary constituents (siliceous, calcareous, and argillaceous minerals, and small organisms), particles of metallic iron. It had a reddish-yellow colour, became black and gave off an empyreumatic odour when heated, and afterwards recovered its yellowish-red colour. The specific gravity was 2·92. The blowpipe showed the presence of nickel, and phosphoric acid was found to the amount of 0·1456 per cent. $P_2 O_5$. Under the microscope small particles of dust were observed, some opaque, others surrounded with a red border, others steel-grey with a metallic lustre. These particles were easily separated by a magnet from the non-metallic more or less transparent particles. The former had a diameter of 0·01 to 0·08 mm. Some were regularly spherical. The dust therefore contains *nickel-iron*, whence it is probably of cosmic origin. Silvestri insists especially on the fact that it did not contain any constituents which might lead to the conclusion that it came from Etna. M. Daubrée examined the dust which fell from April 21st to 25th, 1880, in the Dép. des Basses-Alpes, Isère, and l'Ain. It effervesced with acid, as did the dust of Catania, contained hydrated iron peroxide, spangles of mica, and felspar. It was considered to be dust of terrestrial origin, not volcanic, nor Saharan. About this time, I received from my friend, Dr. Reginald Thompson, of Chelsea, a specimen of reddish powder which had fallen in Algiers in May, 1880. His correspondent, Mr. A. L. Smith, writing under date "Algiers, May, 1880," says: "We have had torrents of rain coming after falls of a red powder in great quantities, of which I send you a little; they say it is meteoric. The sky was yellow: the air quite still. I never saw anything like it." The sand answered in all respects to that examined by Silvestri and Daubrée, it certainly contained particles which were readily removed by the magnet. They were however without action on copper sulphate or mercury bichloride, and the dust did not contain nickel-iron.

### 1880, In Winter. Province Entre-Rios, of the La Plata State, between Nogayá (S.E. of Santa Fé, north of the River La Plata) and Concepcion on the River Uruguay.[2]

Websky reports the arrival of a stone which fell in the winter of 1880 at the place mentioned above, and sent as a present to the Academy. Further particulars are expected to arrive shortly. It fell during an evening and developed a light as bright as day. The piece sent to Europe constitutes one-half of the original aerolite. A crack, started when the stone was broken, has since led to the stone falling into two pieces, weighing 1239 grammes and 974 grammes, The meteorite belongs to the very rare class of carbonaceous stones; its structure is dark grey, has little lustre and is soft; it contains no visible meteoric iron, but an abundance of light grey rounded bodies. among which are occasionally some with a dull metallic lustre and of a greenish yellow colour, and others of a dark grey compact substance and of earthy character.

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[1] O. Silvestri, *R. Acc. dei Lincei*, iv. ser. 3, 1880. *Jahrbuch für Min.* 1881, i. 200. A. Daubrée, *Comptes rendus*, May 10, 1880, xc. 1098.

[2] H. Websky, *Sitzungsber. K. Akad. Wiss. Berlin*, 1882, xviii. and xix. 395.

The meteoric nature of the stone is placed beyond doubt by the crust still adhering to the smaller fragment. When the two pieces are held together, it is easy to recognize which side of the stone was in front during its passage through the atmosphere. The entire stone appears to have had the form of a sphæroid 150 mm. in the smallest and 180 mm. in the longest diameter.

### 1881, March 14, 3·35 p.m.—Pennyman's Siding, Middlesbrough, Yorkshire.[1]

During the past year a very beautiful specimen of a meteorite fell near Middlesbrough, at a spot called Pennyman's Siding on the North-Eastern Railway Company's branch-line from Middlesbrough to Guisbrough, about one mile and three-quarters from the former town. Its descent was witnessed by W. Ellinor and three platelayers, who heard a whizzing or rushing noise in the air, followed in a second or two by a sudden blow of a body striking the ground not far from them; the spot was found to be 48 yards from where they stood. The fall took place at 3·35 P.M. on the 14th March, 1881. No luminous or cloud-forming phenomena are reported. According to Prof. Alexander Herschel, who at once visited the spot, the fall appears to have been nearly vertical. The stone was "new-milk warm" when found, and weighed 3lb. 8¼ oz.; the crust is very perfect and of an unusual thickness, and has scarcely suffered by the fall. The stone forms a low pyramid, slightly scolloped or conchoidal-looking, 6¼ inches in length, 5 inches wide, and 3 inches in height. The rounded summit and sloping sides are scored and deeply grooved, with a polish like black lead in waving furrows running to the base, showing that this side came foremost during the whole of the fusing action of the atmosphere which the meteorite underwent in its flight. The base is equally fused by heat, but is rough, dull brown in colour, and not scored or furrowed. It penetrated the soil to a depth of eleven inches. From experiments made by Professor Herschel, it is calculated that it struck the ground with a velocity of 412 feet per second. As it would acquire this velocity by falling freely through half a mile, it is evident that little of the original planetary speed with which it entered the atmosphere can have remained over.

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[1] A. S. Herschel, *Newcastle Daily Chronicle*, March 30, 1881, Newcastle-on-Tyne. Walter Flight, *Proc. R. S.* 1882, p. 346.

The stone contains 9·379 per cent. of nickel-iron, the composition of which was found to be—

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|---|---|
| Iron | 76·99 |
| Nickel | 21·32 |
| Cobalt | 1·69 |
| | 100·0 |

The per-centage of nickel is high. The remaining constituents consist of rocky matter, amounting to 90·621 per cent., and are soluble silicate 54·315 per cent. and insoluble silicate 36·306 per cent. The soluble silicate appears to be an olivine of the form $2(\frac{1}{3}\,\text{Fe}, \frac{2}{3}\,\text{Mg})\,\text{O}, \text{SiO}_2$, or one closely resembling that which occurs in the Lancé stone, which fell July 13th, 1872, and was examined by Daubrée. The insoluble part is chiefly bronzite, and most closely resembles that which is to be found in the meteorites of Iowa co., Iowa, east of Marengo, which fell 12th February, 1875, and were examined by Dr. L. Smith. The aluminium constituent is doubtless labradorite, and is probably present as some of the occasional chondra which are seen in a microscopic section.

### 1882, January 31st. 2—3 p.m.—Skaufs, Canton Graubundten, Switzerland.[1]

A meteor of rare size and unusual brilliancy was seen in the bright sunshine at several places in the east of Switzerland. A rushing noise was heard at Zurich, at Einsiedeln, and at St. Gallen, and a snow-white lump was seen moving in the air overhead. It threw out a thin yellow band in a north-westerly direction, which appeared to close together again, and break up in a ball-like structure; then it turned red, white, and green, and suddenly vanished. It is said to have fallen to earth at Skaufs with loud detonation.

### 1882, February 3rd, 3·45 p.m.—Mocs, near Klausenburg, Kolosch County, Siebenbürgen.[2]

To eye-witnesses at Klausenburg an intensely brilliant meteor was visible at this hour in a north-easterly direction, the sky was cloudless: at once detonations were heard which was a rolling noise, though at the same time intense detonations were heard. At the spot where the light was observed, a white cirrus-like cloud extended in the form of a white stripe from west to east. The next day it became known that meteorites had fallen at Mocs, five (German) miles eastward of Klausenburg. Dr. Herbich at once went there, and was fortunate enough to receive one weighing 35 kilogrammes, which, after striking an oak tree and lopping off several branches, had penetrated the soil to a depth of 68 centimètres in the frozen ground. Later on a block weighing 70 kilogrammes was found, and a number of other masses. They were spread over an area three miles in length.

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[1] "M." in *Der Naturforscher*, 1882, xv. 87.

[2] F. Herbich, and A. Brezina. *Verhand. der K. K. Geolog. Reichsanstalt*, 1882, 77. (*Der Naturforscher*, 1882, 174.) G. Tschermak, *Anz. Ak. Wiss. Wien*, 1882, 52. A. Koch, *Sitzber. Ak. Wiss.* lxxxv. *März-Heft*, 1882. G. Tschermak, *Anz. Akad. Wiss. Wien*, 1882, 83. A. Brezina, *Anz. Ak. Wiss. Wien*, 1882, 104. A. Brezina, *Sitzber. Akad. Wiss.* lxxxv. *Mai-Heft.* 1882.

Brezina traces the closest resemblance between them and the numerous meteorites which fell 30th November, 1822, at Futtehpur (at Rouspùr, Bithoor, and Shahpùr), they are white friable chondrites. Like them they are traversed by a whole system of black veins, consisting for the most part of nickel-iron and troilite.

Later on Koch concluded that about 2000 stones had fallen, the total weight being 245 kilogrammes. A great number were sent to the National Museum at Klausenburg. The density of the stone appears to be 3·67.

The meteor was seen as far as Verespatak, and traces of the cloud were visible for 15 to 18 minutes. The sun was shining brightly at the time, and the light was strengthened by the reflection of the snow; still the light of the meteor was dazzling. One stone was picked up quite warm. As is usual, the smaller masses reached the earth first, the heavier being carried further to the south-east. A map accompanying Koch's paper shows the way in which the stones were distributed over the area.

Those meteorites which fell on the snow, and were quite uninjured, have a perfect crust which has the lustre of varnish, the average thickness of this crust is ⅛ to ⅜ mm. The large stone has the depressions and hollows usually found on their surfaces. The fresh surface is ashy-grey, in places traversed by brown or black cracks and veins, and sparsely scattered small metallic granules. In conclusion Koch makes a few tentative remarks on his examination of a microscopic section.

Tschermak found on inspecting a great number of the stones that they exhibited a tendency to split up into prisms. The crust is more lustrous than in most meteorites; and long fused threads are occasionally met with. In addition to black veins, there are rarely to be seen broader areas filled with a black magma, as in the stone of Orvinio. Of the definite mineral species white chondra of olivine and enstatite, and brown chondra of enstatite are seen, as well as diopside, a felspar of the plagioclase series, and a black as yet undetermined mineral. Fragments of iron showing very distinct cleavage are also of frequent occurrence.

Brezina still more recently examined the crust and the black veins, and finds that the broad black areas are only met with where the surface exhibits an unusually porous and shrivelled character, properties which fully accord with that of the black chondrites, with the exception of the meteorite of Tadjera, which has no crust whatever, which appears to support the view that they are in each case due to the same cause.

This remarkably abundant fall took place over an area extending from 46° 48′ to 46° 53′ N. and 24° 2′ to 23° 54′ E. of Greenwich.

### 1882, March 9th, 11 p.m.—Between Webster and Oswego, Warsaw Co., Indiana, U.S.A.[1]

Some men who were riding home through a very heavy snow-storm suddenly became aware of a large meteor moving near them with inconceivable rapidity and a rushing roaring noise. It had a bright cherry red colour, "just the colour," as one of the party observed, "of melted iron." The light was so brilliant that it blinded them, and, notwithstanding the storm, lighted the entire neighbourhood as clearly as the brightest day at noon. When nearly overhead it exploded with a tremendous report. The entire party were prostrated, horses and men, and some of them did not recover their sight until some twenty-four hours later. The report was distinctly heard at Warsaw, eleven miles distant as the crow flies, and attracted a good deal of attention. The glass of the windows was broken in a number of houses in the neighbourhood.

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[1] *Warsaw Republican*, March 25th, 1882. Reprinted in the *Evening Times*, of Glasgow, April 15th, 1882.

## REVIEWS.

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CHINA. ERGEBNISSE EIGENER REISEN UND DARAUF GEGRUNDETER STUDIEN. VON FERDINAND FREIHERRN VON RICHTHOFEN. Zweiter Band. Das Nordliche China.

CHINA. RESULTS OF PERSONAL TRAVELS AND STUDIES FOUNDED THEREON. By FERDINAND BARON VON RICHTHOFEN. Second Volume, Northern China. With 126 Woodcuts; a Coloured Landscape; 2 Maps; and 5 Geological Profiles. 4to. pp. 791. (Berlin: Reimer, 1882.)

IN this massive volume Baron Richthofen continues his descriptions of the physical features of China, of which the first portion appeared about five years since. The present work is restricted to the northern portion of that widely extended country, and presents to us the geological features of an extensive area hitherto completely unknown to science. The observations recorded were for the most part obtained in the course of a series of rapid journeys through the different provinces of the country, during which the author accumulated a vast amount of geological details, which are here given very fully. Fortunately for the reader a *resumé* is given of the geological features of each province, and also a general summary of the country as a whole, and the verbal descriptions are accompanied by excellent maps, woodcuts of scenery, and numerous geological sections and profiles, so that the routes followed by the author can be followed without difficulty. Though mainly devoted to illustrating the physical characters, the work at the same time includes a description of the climate, the economical productions of the soil, and the character and occupations of the inhabitants of this country, so as to permit a fairly complete picture of its conditions under these various aspects to be formed therefrom.

The geological history of China is referred to three great periods; the first of which comprises the formation of the Archaic rocks, and the mighty disturbances to which they were subjected; the second begins with the deposition of a series of rocks of great thickness, to which the author applies the term *Sinisian*, and extends to beyond the termination of the Carboniferous; the third period begins with the upheaval of the whole district after the deposition of strata of the Rothliegende epoch, and continues to the present time.

The oldest and basement series of rocks are beds of ancient gneiss and granitic gneiss, which have a very wide and general development, and are characterized by a steep dip and a prevailing strike of N. 30 W. On the denuded and abraded surface of this *Urgneiss* there occur beds of newer gneiss, also of hornblendic and chloritic gneiss, varying in petrological characters, and in the direction of the strike to the older beds. These rocks in some districts form elevated and rugged mountainous areas. These gneissoid strata, both older and younger, are regarded by the author as the equivalents of the Laurentian system of other continents, and may be distinguished also from the newer metamorphic rocks by the absence of beds of crystalline limestone. Resting unconformably on the gneiss is a series of beds of great thickness, and of very varying petrological characters in different localities, but which appear to be of the same relative age. These strata consist of mica-schist, hornblende-schist, quartzite, sandstone, coarse conglomerate green schists, and crystalline limestones. In one district this series has an estimated thickness of at least 10,000 feet, and the author parallels the series with the Huronian system of other countries. At the close of the deposition of this group of beds a mighty revolution occurred, in which they were highly plicated and faulted, and in some places penetrated by eruptive rocks. The author states that the rocks of this first main period were uplifted to form the skeletons of mountain ranges, and their surfaces experienced enormous and long-continued denudation before the commencement of the deposition of the lowest beds of the second main period.

The next succeeding group of rocks form the Sinisian system; it has an extremely wide development, and is readily recognized by similar petrographical characters in areas far apart from each other. The group consists of three series: the lower, a reddish sandstone with local developments of quartz breccia; the middle, of siliceous limestones with beds of red clay-shale and sandstone; and an upper series of globulitic limestone, in which the earliest fossils, consisting of fragmentary Brachiopods and Trilobites, are met with. The detailed description of these and other fossils is reserved for another volume, but Professor Dames states that the trilobitic fauna of these limestones chiefly consists of examples of the genera *Dikelocephalus* and *Conocephalus*, and bears a closer resemblance to those occurring in the Potsdam sandstones of North America than to those of the Swedish Cambrian strata. The concordant series of beds of the Sinisian system vary in estimated thickness from 12,000 to 20,000 feet. The higher portions of the series are placed by the author as equivalents of the Cambrian system.

Over the greater part of Northern China an elevation of the surface appears to have taken place at the close of the Sinisian or Cambrian period, no representatives of Silurian or Devonian strata appear to be present, and the Sinisian beds are immediately succeeded by Carboniferous strata, frequently exhibiting an apparent conformity with the underlying Cambrian. In the province of Shensi, however, there is displayed a great series of shales and limestones, estimated at 20,000 feet in thickness, which, by their fossils, plainly show that they belong to the intervening periods. Some of these beds are nearly entirely composed of corals of common Silurian genera, and mention is made of platter-shaped examples, probably of *Favosites* or *Alveolites*, which attain the dimensions of a waggon wheel. According to Professor Lindström, these coral beds are of the age of the Wenlock, and overlying them, limestones occur with distinctive Devonian Brachiopods; then follow Carboniferous limestones, so that in this district there is a complete conformity of the strata from the Silurian to the Carboniferous. In other localities the Silurian strata were penetrated by a great granitic outburst, accompanied by colossal faults, before the deposition of the Carboniferous.

The lowest beds of the Carboniferous consist of limestones, frequently bituminous, and with hornstone nodules. Their age is definitely established by the presence of *Producti*, *Spirifers*, and other fossils. Above these are beds of sandstone and shales with productive coal beds. The extent and importance of the workable coal strata of Northern China are clearly shown by the author not only in the detailed descriptions of the various basins, but also in a special chapter in which a review is given of their position, the thickness of the seams and the character of the coal present in each province. The most remarkable of these coal basins appears to be that of the Anthracite district in the South-east of the province of Shansi. It comprises an area estimated at 10,150 geographical square miles, throughout which a workable thickness of 40 feet of coal appears to be present, which would give an amount of 620,000,000,000 tons of coal. Along a line of 180 miles in length, beds of Anthracite from 15 to 30 feet in thickness could be worked at almost any point. The anthracite is of excellent quality and is compared to the best in Pennsylvania. Nor is the coal the only product of this district, for in close proximity there is an abundance of excellent iron ore. In other portions of this province the author estimates that bituminous coal, equal in quantity to the anthracite, is present, and this latter alone would be sufficient to supply the consumption of the world, at its present rate of 300 million tons annually, for 2100 years. At the present time these coal strata are worked only on a very small scale, and at the mine the cost of the coal per ton is somewhat under two shillings.

Most of the highland areas of the North of China appear to have been upheaved at the conclusion of the Carboniferous period, and only in one or two localities have rocks of Permian or Triassic age been noticed. In one place, however, variously tinted limestones, 1000 feet in thickness, are supposed to belong to one or other of these systems; and overlying these are beds of sandstone and clays with thin seams of coal, in all over 2000 feet in thickness. Judging from the plant remains these strata belong to the epoch of the Lower

Jura. Mesozoic strata of a later date, and older Tertiary strata, do not appear to have been yet recognized in Northern China.

Of relatively recent geological date are the remarkable widespread deposits of Loess, which sometimes attains a thickness of over a thousand feet. Perhaps no more striking phenomena than these wonderful deposits occur in the whole range of stratigraphical geology, whether we take into account the character of the deposits or the manner of their production. The author has lately given in this MAGAZINE such a lucid and graphic description of the characters and origin of the Loess, that it is not necessary here to refer to the facts brought forward respecting it in this volume.

The author's conclusions that it is to be regarded as the product of Æolian influences acting during periods of long duration and under different conditions of climate, appear to be fully justified by the mode of its occurrence not only in China but in Europe as well. In Northern China, three of these climatic periods are distinguished:—(1.) An erosion period, in which the surface of the country was sculptured by erosion and denudation into the figure it still retains beneath the covering of Loess. (2.) A Steppe period, in which the conditions of the saline steppes of Central Asia were extended over the area of Northern China. (3.) A Loess period, now existing, in which, through a moist climate, the former Steppe-districts have been converted into Loess districts.

The author devotes a chapter to considering the effects of marine action on a coast-line in forming planes of denudation, and arrives at similar conclusions to those enunciated long ago by Professor Ramsay.

In concluding this short notice we can but express the opinion, which we feel must be shared by all who consult this grand work, that this book is a most valuable and important contribution to geological science. It presents us with the main outlines of the geological characters of a vast area of country of which nothing had been previously known, so that we are enabled now for the first time to correlate the succession of the strata in China with that of other countries. The difficulties attending an investigation of this character are readily apparent, for not only were the geological features quite unknown, but even the topography of the country was to a large extent a blank, and beyond the position of a few of the large cities and the course of some of the larger streams, the land was a *terra incognita*. Under these circumstances we can appreciate the arduous nature of the undertaking and the qualifications necessary for fulfilling it, and we warmly congratulate Baron Richthofen on having accomplished it so successfully. We are very glad to know that in a short time the descriptions of the fossils, which have been entrusted to several eminent palæontologists, will be published in another volume, and we anticipate that the fossil flora and fauna of this area will prove not less interesting and valuable to science than its stratigraphical features. G. J. H.

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## ORIGINAL ARTICLES.

### I.—Traces of a Great Post-Glacial Flood.

### 4. Evidence of the Angular Drift.

By H. H. Howorth, F.S.A.

WE have sifted the evidence furnished by the Loess, by the loams and brick-earths, and by the valley terraces which are such conspicuous features in the surface geology of Europe, and we have found them furnishing a perfectly consistent and perfectly reasonable story. We have still left for consideration the most eloquent for our purpose of all the surface deposits, namely, the great sheets of angular gravel which many of us have examined with curious interest for many days, and which mantle so much of the land on either side of the English Channel.

The chief characteristic of this gravel is that it is for the most part composed of broken flints with unrubbed edges, whence Murchison called it the Angular drift. This character it bears on both sides of the Channel; and there can be no doubt that as it occurs at Sangatte, etc., where it has been described by M. d'Archiac and Mr. Prestwich, it is, as those authors urge, identical in origin with the drift capping the cliffs at Brighton and at Bournemouth. This drift has given rise to much discussion, and, as in previous papers, we will first examine the theories which have been recently current about it, and conclude with our reasons for adopting a wide-spread inundation as the *vera causa* alone competent to meet its conditions. Every inquirer who has examined the question is agreed upon one fact, which is indeed palpable, that the flint drift we are discussing was distributed as we now find it by water. Once it was supposed that it was a marine deposit, but this view is no longer held anywhere. The fact that the flints are for the most part unrolled quite takes the deposit out of the category of a marine shingle, nor again do we find in it such traces of marine organisms as would inevitably be present if it had been a marine deposit. Upon this point Murchison's observations are most just. He says: "If an arm of the sea had permanently occupied this tract during each of the long periods in which the advocates of gradual causation suppose the strata to have been successively broken, crumbled down and washed away, we ought to find some relics of the water-worn shingle, of former times, along the numerous escarpments of Upper and Lower Greensand, etc., if not along the edges of the escarpments of the chalk or chief shores of former seas. But if not along those main shores, the narrows by which the great bay communicated with the ocean (for such the transverse valleys must in that case have been) ought especially to present to us lines of water-worn shingle, something like the beaches of our own coasts or the raised terraces of Norway. We ought, at all events, to be able to detect as good evidences of the former abode of the sea as are observable in the Valley of the Severn, or former 'Straits of Malvern,' and other parts of England, where sea-shells and shingle co-exist. On the contrary, we find that . . . it is just in such gorges that there are patches in the recesses, not, however, of the rounded materials which long-continued tidal action of waves would produce, but of irregularly-formed angular or subangular flint gravel and drift, not bedded, and arranged at definite heights above the present drainage, but arrested at various altitudes or lodged in the lowest depressions; *all the remains which can be detected in them being exclusively terrestrial*, except on the southern sea-shore. Occasionally, indeed, the drifted materials are found dovetailed into the cavities of the fractured bones, and land-shells of existing species are found in the loam, commingled with the lost species of quadrupeds" (Journ. of the Geol. Soc. vol. vii. pp. 392–3).

Again, the same most experienced observer says: "There can be little (doubt) in affirming, that neither during the operations which deposited the debris, nor after them, was the Weald valley occupied by the waters of the sea, or its transverse gorges by marine narrows. There is not a single rounded pebble along the lower edges of any of the escarpments that flank the central Wealden; still less does the tract contain any fragments of marine shells; whilst by far the greater part of the detritus is just that which must have resulted from an action which left the shattered debris in positions and conditions which no ordinary sea would have done. Nor can it be suggested that along hundreds of miles of natural escarpments, the supposed lines of deposit of ancient sea-shores, are all now hidden under spoil resulting from the diurnal action of ages. The rocks *in situ* are everywhere at or near the surface, and nowhere is there any symptom of action of the sea." Again, "All the fossils found inland are terrestrial" (*id.* p. 393).

Again, he says, "Wherever you examine this detritus, whether it be on the external slope or talus of the chalk hills, or in the broad, slightly inclined flats extending to the sea, you find that, whatever may have been the materials acted upon, they have all been violently broken up and gathered tumultuously and without a symptom of having been subjected to ordinary tidal coast action to produce stratification, or long-continued aqueous abrasion to round the flints; nor do they anywhere contain marine remains, except where the detritus has been shed off into the low situation, at Hove, and has there encroached upon the sea-level" (*id.* p. 372). Lastly, he says, "Any ordinary tidal action we can conceive would have left signs either of successive sediment or of water-worn pebbles, and would not have afforded the clear proofs that have been adduced either of *sweeping* denudations down to the bare framework of the rocks, or angular drift distributed in bands and patches at different altitudes. accounting for such facts the advocate of the tidal action of the ı meets with insurmountable difficulties at the very threshold of ; position. Instead of rounded pebbles of the last-formed detritus the South-East of England, he sees both on this side and on the ıer side of the Channel near Calais, that where there is a true ıter-worn beach, it lies between local drifts in which all is fragentary and tumultuous; and hence he is not authorized to appeal the mere forms of the escarpments of chalk or to insulated pyraıids or outliers of that rook as proofs that the sea, as we now underınd its action, could have produced any such results" (*id.* p. 394). r. Belt speaks in the same strain and says, "There is this insuperle objection to the theory of marine submergence, that over the hole district (*i.e.* Devon and Cornwall) no marine beaches and not single marine organism has been found excepting within a few feet the present sea-level. Nor can sea-shells have once existed in e deposits and been since destroyed; for mammalian remains and nd shells and freshwater shells are preserved, and any agency that ould have obliterated the traces of the one, would not have spared the hers" (Journ. Geol. Soc. vol. xxxii. p. 84). These extracts will ffice, for I take it we are merely killing the dead in arguing against e marine origin of the Angular drift. I am not aware that it has en suggested that this drift was distributed by ice action; but if ıy one should suppose so, I think the following sentence from urchison's paper just quoted will be conclusive. He says that we ıve not "in discussing the question of the Wealden denudation and e formation of its local drift, the power of invoking the agency ice, as in the more northern tracts of England and Scotland ıd over large portions of Ireland. Here we cannot appeal to rrestrial or sea-borne ice, to get rid of the difficulty of tumultuous cumulation, by supposing that icebergs impinged upon alluvial atter. For no one has yet ventured to suggest, that the heights of utser, Hind Head, or Leith Hill were the abodes of glaciers, nor ıs any one detected appearances in the drift within or without the 'ealden area which can be considered to have resulted from the echanical action of ice; still less have any species of arctic shells far-transported blocks ever been observed within the area affected" *p. cit.* p. 395). Mr. J. Evans, following Sir Charles Lyell, argues a paper on the Flint Implements of Hants and Wilts, that the rge blocks of sandstone in the gravel and on the shore near Hill ead in Hampshire were transported by ice action, adding, "that ıe chalk flints in the gravel, which must have travelled a distance at least twelve miles, and some of which are, nevertheless, ıtirely fresh and unrolled, testify to a similar means of transport" ourn. Geol. Soc. vol. xx. p. 193). In my view these facts, instead requiring the predicate of ice action to explain them, testify most owerfully in favour of a translating flood of water.

We will now turn to a theory which has monopolized attention r some years past, and which has the imprimatur of some good ames, among them of my most accomplished friend just named, Mr. John Evans. According to this theory, the gravel which is so conspicuous in Hampshire and the neighbouring districts is of fluviatile origin and marks the bed of an ancient river, which once flowed in a direction parallel to the present coast-line, and of whose channel the present Solent was once a part. I confess that I am utterly bewildered how to reconcile this theory with the facts as I have examined them with patience and care for many days in this part of England. In the first place, the gravel presents no single feature which seems to me compatible with its having been of fluviatile origin. It contains no debris of fluviatile organisms, no remains of shells, etc., etc., which lived in such a river. Such remains are common in river gravel properly so-called. Mr. Belt says, "When travelling in Russia, I examined the sands and gravels of the beds of the larger rivers. These rivers are frozen over for several months in the year, and it seemed likely that the conditions would be somewhat similar to those that are supposed to have existed in the valley of the Thames at the close of the Glacial period. Much of the sand and gravel from the rivers of Southern Russia was used for ballasting railways, so that I had many opportunities of examining it. *I found it in every case full of river-shells*, and sometimes one-half of the whole mass seemed to be shells. There were three species of *Unio*, and the little *Neritina fluviatilis*, especially abundant. Where gravel from the bed of the Thames is now dredged up, it also contains many shells." In the Angular drift we find no river-shells, but on the other hand, as in the loess and the loams that have occupied us in previous papers, we have many remains of a purely terrestrial origin, land-shells, bones of animals, and worked flints, the debris of primitive man.

If we turn from the contents of the beds we are describing to their texture, we shall be even more impressed with the difficulty of assigning a fluviatile origin to them. A very large proportion of the flints in these gravels is remarkable for being unrolled and unweathered. The fractured edges are sharp and unrubbed. Mr. Searles Wood, to whom we are all so exceedingly indebted for having brought light into the chaotic regions of surface geology, describes very graphically the nature and condition of these flints. He says, speaking of the mixture of the rolled pebbles from the Tertiary beds with the unrolled flints: "The especially noteworthy feature connected with this intermixture is that the pebbles and the angular flints present no intermediate grades of rolling to connect them; so that it is obvious this admixture of angular flint and Tertiary pebble cannot, in finding its way to the positions it occupies, have undergone any *considerable or repeated amount of wear by transport*. Instances occur, moreover, in which chalk fragments have occurred in this intermixture. Considering how impossible it is for chalk to sustain without dissolution any *long-continued aqueous action*, this circumstance is also of much importance." Speaking of these facts Mr. Wood says: "This feature seems to me repugnant to any presumption that these pebbles have settled down into their present places by successive transport from higher to lower levels uring a long-continued fluviatile denudation—because such a sucessive and long-continued transport could not have failed to grind he smaller pebbles into sand, and to reduce the angular flints into ll stages of wear, connecting them with the pebbles themselves" Journ. Geol. Soc. vol. xxvii. pp. 9, 10). This is assuredly most ound, and it seems to me to make the fluviatile theory impossible. River gravels are so common, and can be studied so easily, that it eeds only a very elementary survey to predicate of them that they nvariably consist of rounded and rubbed pebbles, the result of the rinding action of the stones against one another in the narrow roughs in which the river flows.

In addition to the angular pebbles, the gravel also contains in nany places, as is well known, masses of greywether sandstone. The evidence furnished by these is absolutely at one with that f the angular flints. They have the same angular edges, which reclude their having been rubbed and scoured by river action. f we turn from the more solid contents of the gravel to the matrix n which they are imbedded, we have the same story to tell. The ebbles in river gravels for the most part are washed clean, or at all vents are not imbedded in a loose matrix of loamy sand such as is hat which characterizes the angular gravel of the South of England, nd characterizes it in a very homogeneous way over a very wide xtent of country. Again, in the deposits which are unmistakably luviatile, the beds are arranged in stratified fashion, and there is to be een evidence of a long-continued and secular deposition of materials. Here, on the contrary, evidences of stratification are almost entirely vanting, the arrangement of the materials of the gravel is often nost irregular and tumultuous, a very good specimen of this rrangement being the one to be seen in the well-known Sugar Loaf Chine west of Poole Harbour. In many places, again, we have treaks and slabs of sand of more or less lenticular shape intercalated mong the gravel. In these features surely we have every sign that he gravel was anything but fluviatile. As Mr. Belt says of similar leposits somewhat further north than the area we are considering: 'The irregular and fitful stratification, the short lenticular patches f sand, the mixture of sand throughout the gravel, the large stones t the base, the great proportion of broken flints with slightly worn ngles, and the occasional oblique lamination, are all opposed to the heory that the deposit is the result of successive layers of materials rought down by a river at different times" (Quart. Journ. of Science, 2nd series, vol. viii. p. 329).

Let us now turn to another feature of these gravels. If they had een deposited in a river channel, we should surely have found that hannel where we can examine it marked by the usual features of luviatile beds, scoured into a tolerably uniform trough, but here, as nay be seen in the magnificent sections exposed along the English Channel, the gravel lies on the torn and ragged surface of the nderlying soft strata, which is torn and scooped in such a violent nd irregular manner with projecting beaks, etc., that it is incredible ow any river action could have first formed it.

Again, the gravels are found capping the cliff at various heights up to at least 100 feet, which would require that the river should have once flowed at a much higher level. If the level of the gravel had been tolerably uniform, this might have been said; but as it follows the contour of the rolling surface running down the Chines, and along the crest of the highest ground, it is difficult to see how a river could have deposited it. In walking from Bournemouth to Poole the position may be studied with the greatest clearness. On the easterly side of Poole Harbour the gravels are deposited almost at the sea-level, while near Bournemouth they rise to over 100 feet above the sea-level. I walked over the ground with great care in many directions, and everywhere with this fluviatile theory in view, and was everywhere impressed with the fact that unless a running stream can run uphill as well as down, and can follow a rolling surface independent altogether of the drainage of the country, that it would be literally impossible for a river to deposit these gravels. It may be said that the whole section has been since disturbed, and that the rolling contour has been given to the country since the deposition of the gravels. Of this not only is there no evidence, but the evidence is entirely the other way. The greatly extended accumulation of gravel that occurs on the sides of the Chines, and the general absence of twisted or curved lines of stratification in the subjacent strata, make it clear that the gravel, whatever the cause of its distribution, was spread over a surface whose contour was practically the same as that the country has now.

Again, whence could such a mass of uniform gravel have been derived? The river, as postulated by those who make the gravel fluviatile, must assuredly have been a considerable river. Where in any considerable European river do we find gravel deposited in this way? In the Rhine, the Rhone, the Elbe, the Dwina, the Po, the Don, and the Volga, the deposit is almost entirely that of a fine mud, such as forms the greater part of known Deltas; but here we have a river extending for at least 200 miles, and depositing angular gravel all the way. Whence was the material derived? If it be the product of denudation of the river channel itself, how comes it that the channel is choked with gravel? A river cannot at the very same place scoop out chalk and lay down flints; a very small layer of gravel immediately protects the strata on which it rests from denudation. Mere local patches could be easily accounted for, but a continuous mantle from 6 to 18 feet deep, and uniform in texture, whether overlying Cretaceous or Tertiary beds, is a very different thing. Again, such a river must have been of enormous size. So long as we keep our eyes on the Solent, and find both sides of it occupied with similar gravel, we may speak of a river of modest proportions; but when we find that this gravel is found not merely on both sides of the Solent, but on both sides of the English Channel, and extends in France from Sangatte to the Cotentin, we are taken aback when told that such gigantic proportions have ever been attained by any European river. Where was the drainage area for such a river, which can be compared for size only with the

Mississippi and the Amazon? Whence could its water be derived? Whether we adopt the view of Mr. Codrington that it flowed from West to East, or that it included the drainage of the waters of the rivers that now flow into the North Sea, we are met by a stupendous difficulty in postulating a river in the West of Europe 40 or 50 miles wide, and, be it remarked, a rapid river; for if it were a sluggish river only, it would deposit mud, but not gravel. The fact is that every way we look at the problem when we sift it candidly, we are met by difficulties, inconsistencies, and contradictions, that make it impossible for us to regard the fluviatile theory as admissible.

If we exclude marine and fluviatile action, where are we to turn for a cause sufficiently patent and competent in other ways to spread the angular gravel as we find it—where are we to turn, but to the cause which we have already postulated so frequently? This appeal in the case before us is not a new one. It is merely a reversion to the views held before Lyell's influence became so overpowering as to constitute almost a religion.

Long before I wrote these papers, much more distinguished observers than I can ever hope to become accepted a view more or less in harmony with that here defended, and I shall not scruple to turn to them and to quote them freely. It is the fashion in some places—a fashion which I confess to dislike exceedingly—to minimize as much as possible the work done and the results obtained by those on whose shoulders we stand, because standing there we naturally see further than they did. That there were great men before Agamemnon is a precept which has lost its force among some students of geology. The old men were surely as honest, as keen-sighted, and as well-furnished with keen wits as we are. The evidence they had before them was very much the same as that we have, and it follows that in many cases where fashion has turned elsewhere, it may be prudent to reconsider its steps and to turn once more to their teaching. To call that obsolete which merely trenches on our prejudices, and is not inconsistent with the facts, is to indulge in mere rhetorical word-play. We have no respect whatever for authority as such. But when a man, whose reputation it is the fashion rather to paint in chiaroscuro because he lived before the epoch covered by our immediate memories, spoke a great truth, he ought to have credit for it; and we are equally trenching on questionable morals whether we appropriate his discovery or refuse to recognize it because he lived before the days of our own prophet. The older writers no doubt based some of their reasoning on certain postulates which are no longer tenable. No one now would dream of suggesting that a *Universal deluge* or *Noachian flood,* such as formed the background to Dr. Buckland's famous treatise, is evidenced by the facts as we know them. We at once brush aside not only this, but all other general postulates as utterly vicious. We hold that to face the facts hampered with the postulate of a Universal Deluge is as vicious as to do so hampered with the equally crippling postulate of uniform action *in sæcula sæculorum.* The facts alone are our masters, and if a certain number of them are explainable on no other hypothesis than one which we derive from them by induction, we hold that until facts are forthcoming inconsistent with it, we are bound to receive it, however many cherished prejudices have to go to the wall in consequence.

(*To be continued in our next Number.*)

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## II.—THE CHLORITIC MARL AND UPPER GREENSAND OF THE ISLE OF WIGHT.

By MARK W. NORMAN, of Ventnor.

(PLATE X.)

IT will no doubt be remembered by some that as far back as the year 1858, in "The Geologist," Vol. I. pp. 480 and 509, I published a paper upon the Chloritic and Fossiliferous Marls, with some remarks on the Upper Greensand, of the Isle of Wight, my object being to point out the difference between these deposits, and their organic remains, with the view to their separation; stating as a reason that the fossils and deposits of the upper beds which intervene between the Chalk and the Upper Greensand were a distinct formation, and contained distinct fossils from those of the beds below.

But like much that has been written upon the subject, both before and since, the paper was no doubt defective, especially in the nomenclature of the fossils. Still, the main facts remained.

But little, if any, interest was taken in the matter at the time, and I therefore concluded that the subject had been disposed of by the eminent authorities who had gone over the ground before. It appears that this was not the case, however, as the visit some time ago by a French geologist (M. Barrois) to the Island has led to inquiry, and some controversy, and it now appears that little or no attempt had been made (with but one single exception), with the view of ascertaining the changes in the deposits at different heights, and the horizontal range of their fossil contents.

Having had some little experience during the many years in which I have been working on the geology of this district, with diffidence I now venture to offer a few facts in addition to and including those which I published in 1858.

For this purpose I have carefully measured the strata as a whole, and for convenience have divided the series into four divisions, and separated the fossils found in each division. In the description of the strata I have again divided them into sections, as will be seen by the accompanying Diagram (Plate X.).

### *First Division.*

With respect to the lower fifty feet of grey micaceous sand and clay, locally termed "rubble Gault," after a careful examination of it at different heights from the Gault proper, I found no fossils which could be identified. All that could be detected were some fragments of shells scattered through the upper portion, which were in such a friable state as to be quite untransportable.

I therefore propose to take as a basis a bed of what appears to be

# GREENSAND AT VENTNOR, ISLE OF WIGHT.

*IV. NORMAN.*

*us, Turrilites tuberculatus, Belemnites minimus, Ammonites rostratus, A. Mantellii,*
*Vectensis, Ostrea carinata, O. vesicularis, Pecten asper, Pleurotomaria,* various
*ys.* [bodies.
*quecostatus,* teeth and vertebræ of Shark (*Lamna*), Saurian remains, various spongoid
*icularis,* with crushed *P. quinquecostatus* and *P. asper* (derived), *Exogyra conica,*
*ula biplicata, Trochocyathus,* Teeth of *Lamna.*

odies. Fossil coniferous wood, *Pecten quinquecostatus, Exogyra (Ostrea) conica,* most
*s inflatus, Nautilus* filled up with chalcedony, Teeth of *Otodus* and *Lamna.*

*Nautilus radiatus, N. pseudo-elegans, Pecten orbicularis, P. elongatus, Cucullæa,*

odies, *Siphonia Websteri, Pecten orbicularis, Exogyra.*

*varians, Trigonia sp.*

*rostratus.*

: *Ammonites inflatus, A. rostratus, A. sp., Panopæa plicata, Serpula antiquata,*

*A. sp., Panopæa plicata, Trigonia alæformis, Pecten orbicularis, P. qinquecostatus,*
*olatus, Rhynchonella latissimus, Cardium gentianum, Ostrea conica, Vermicularia.*
*ossarius, Siphonia Websteri, Hoploparia Saxbyi,* Chelonian remains, etc.

*mi.*

ETHERIDGE, F.R.S., F.G.S.
TO ONE INCH.
SCALE BY R. H. SCOTT.]

Gault, being much darker and more compact than the grey micaceous clay and sand on which it rests, indicating an almost sudden change from these to Gault. It contains in some places masses of a dark shaly substance, and is full of the remains of *Serpula antiquata.* At its base is a thin band of hard blue chert containing the crushed shells of a large *Inoceramus*; on the top of which is another bed of the same material also containing *Inocerami* in a more perfect condition, with *Panopæa.* The total thickness of these lower beds is about three feet; they contain the first organic remains which can be recognized in the series.

The next thirty feet above consists of soft yellow micaceous sands, divided by layers of large nodules or concretions of Rag, about five or six in number. These nodules, in shape like a compressed cone, are circular, and measure from a few inches to three or four feet in diameter. Nearly all of them, especially those of the lower zones, contain, with the layers of Rag, many fossils, such as large *Ammonites* (*A. rostratus, A. inflatus*); and groups of fossils often occur in them. Some of the lower concretions have a central elevation, and some have a phosphatic tube-like structure in the centre, often four or five sided; they are quite common in the lower beds of the black shaly masses mentioned.

The layers of Rag and nodules are all coated with the soft micaceous sandy matrix in which they are imbedded, which weathers off on exposure to the elements, often exhibiting fossils in relief on their surfaces, especially in the cliffs East of Black Gang Chine. It was from one of these that Mr. Saxby obtained his specimen of *Hoploparia Saxbyi* on the shore at Ventnor.

This fossil is by no means confined to these lower beds, but ranges through this and the next division also.

### *Second Division.*

This division I propose to name the Sandstone and Rag-Beds: it ranges from the before-mentioned series up to the Firestone.

The first is an irregular stratified bed of hard blue chert, with nodules of the same. Some of the detached nodules are full of *Serpula antiquata,* with other fossils; *Ammonites rostratus,* and a large *Ammonite* with a rounded back; *Pecten orbicularis,* etc. Resting upon this band is a bed of compact reddish-brown sandstone ten feet thick, streaked with black lines, which contains many fossils in the lower three or four feet; *Ammonites rostratus,* with other unnamed *Ammonites. Panopæa* is also common. This is succeeded by another bed of Rag of one foot; and ten feet of sandstone of the same lithological character as the bed below, but more compact, which, excepting the large *Ammonites rostratus,* contains but few fossils.

Resting upon these beds is a thick bed of Rag, and seven alternating beds of soft sandstone, divided by another layer of large conical flattened concretions called by quarrymen "Whills," which contain fossils such as *Limas, Pectens, Terebratulæ,* etc. These again are succeeded by two bands of darkly streaked laminated sandstone containing a species of *Cardiaster,* with a *Panopæa,* this is called the "Black Band." Resting on it is a layer of Rag, with a bed of soft sandstone of a light grey colour, sparsely fossiliferous; succeeded by another bed of Rag of one foot, which rests upon a band of light grey sandstone of about four feet thick; it contains no fossils except large groups of semi-silicified sponge-like bodies.

Another bed of hard blue Rag one foot thick succeeds this, upon which is deposited a thick bed of close-grained grey sandstone of great economic importance, being in much requisition for building purposes, which, with a soft bed of the same material on the top, is about five feet thick. It is locally termed the "freestone bed," and is more compact and harder than the beds below it. This bed is quarried and sawn into blocks for quoins, etc., of buildings, and is conspicuous for its thickness compared with the other beds along the face of the cliffs which form the great wall of the Undercliff between Ventnor and Blackgang. It is from about 32 feet to 34 feet below the Lower Chalk.

Next in ascending order is an upper bed of Rag one foot thick, on which rests the so-called "Firestone" bed (by which Dr. Mantell proposed to name the whole of the deposits); which is after all but a very subordinate member of the group, consisting merely of a bed of hard laminated sandstone, from 8 ins. to 9 ins. thick; and a layer of Rag 9 ins. thick, succeeded by an upper bed of the same lithological character; the whole averaging about two feet in thickness. This bed was locally called "Firestone" by the old inhabitants of the Undercliff, and used as a substitute for bricks for fire-places and the bottoms of ovens.

### *Third Division (Chert Beds).*

This division consists of from twenty to twenty-four beds of chert and laminated siliceous sandstone alternating with each other and very unevenly bedded throughout, some of the beds varying in thickness from a few inches to two feet; the seams of the sandstone being interstratified with large concretions of Rag, in the same line of bedding. The layers of sandstone vary much in thickness.

This division also contains three or four beds of black and dark grey flinty chert, the lowermost of which is about two feet thick, and called by Dr. Mantell "coarse chalcedony." The upper beds are crowded with spicula of sponges.

Besides these, there are several thin bands of white brittle chert, apparently siliceous, and breaking into square fragments.

This series of deposits is very sparsely fossiliferous, the fossils being chiefly derived. Some of the layers contain comminuted shells with single waterworn valves of *Ostrea conica*, etc.

I have upon two or three occasions discovered a large *Nautilus* in the upper beds of this series of deposits, the chambers of which were filled with a dark blue chalcedony.

### *Fourth Division (Chloritic Marl,* etc.).

Deposited upon a seam of irregular-bedded Rag, being the topmost layer of the chert beds, is a layer of laminated pea-green sand, about one foot four inches thick, which indicates an almost sudden change in the deposits. A thin seam of comminuted shells runs through this, with numerous entire single valves of *Pecten orbicularis*, and *Pecten quinquecostatus.*

An irregular layer of misshapen phosphatic nodules is imbedded between the last-named layer and the Chloritic Marl above. These nodules are derived; many of them have the remains of sponges and shells adhering to them, and some of them have the appearance of having been pierced by *Lithodomi.* Interstratified with them are various species of Sponges, Polyzoa, etc., with Shark and reptilian remains. Imbedded on these nodules is a seam of green sandy materials marked by meandering lines, and patches of marl upon the upper part, which is unfossiliferous in the neighbourhood of Ventnor, particularly in the lower part, in contact with the nodules. This seam is of a dark green colour, and contains Saurian remains, with *Pecten asper, P. orbicularis*, and *Pecten quinquecostatus.*

Upwards from the dark green sandy bed the deposits gradually merge into that of a light grey colour with dark grains. In some localities this bed is permeated by iron, but its composition partakes largely of marl; this is the first indication of a change from chert Rag and sandstone to the Chalk into which it gradually merges. It is full of fossils and fragments of fossils, and sponge-like bodies, mostly phosphatic, and *Ammonites.* It weathers easily, when numerous fossils are exposed in relief on the surface of the fallen blocks which strew the shore of the Undercliff.

From the waterworn appearance of most of the organic remains they seem to have been derived from some older stratum, and to have been deposited under the influence of strong currents. Curiously enough, I came upon two distinct specimens of *Ammonites rostratus*, a short time ago, in the Quarry at the Railway Station, which I have never before met with above the five feet building stone, upwards of thirty feet below.

A large per-centage of the fossils have their equivalents in the Chalk Marl, in which has been found *Nautilus pseudo-elegans, N. expansus, Ammonites rostratus, A. Mantelli, A. varians, Pecten asper, Ostrea carinata*, etc.

With reference to the diagram, I must acknowledge the great assistance rendered me by Mr. R. S. Scott, the Town Surveyor, of Ventnor, in drawing it out, and reducing the measurements to scale.

I am also greatly indebted to Barnard Meyers, Esq., of the Belle-Vue Estate, Ventnor, for allowing me free access to the Quarries on the Estate, by which I have been enabled to procure many specimens of organic remains, and who also presented me with several large *Ammonites* which I have included in the collection for the British Museum which accompanies this paper.

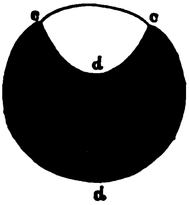
## III.—NOTE ON *ELLIPSOCARIS DEWALQUEI*, A NEW PHYLLOPOD CRUSTACEAN SHIELD FROM THE UPPER DEVONIAN OF BELGIUM.[1]

By HENRY WOODWARD, LL.D., F.R.S., F.G.S.,
of the British Museum (Natural History).

THE specimen which forms the subject of this note has been kindly placed in my hands by Professor G. Dewalque for examination, and is of extreme interest and importance to me in my researches upon the Fossil Crustacea. It is *not*, as was at first supposed, the metastome of *Eurypterus* or of *Pterygotus*; on the contrary, it represents an almost entire carapace of a new genus and species of Phyllopod Crustacean allied to *Peltocaris*.

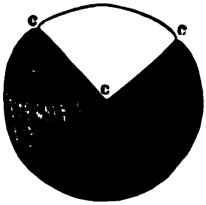
The name *Peltocaris* was given by Mr. J. W. Salter, in 1863,[2] to a circular head-shield of a Phyllopod from the Llandeilo Flags, Dumfriesshire, having a semicircular cervical suture (*c*, *d*, *c*) and a straight dorsal suture (*d*, *d*) (Fig. 1).

FIG. 1.



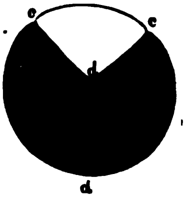
*Shield of Peltocaris.*

FIG. 2.



*Discinocaris.*

FIG. 3.



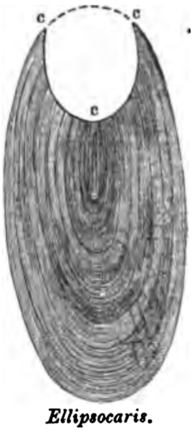
*Apthycopsis.*

In 1866,[3] I described another form of head-shield of a Phyllopod from the Lower Silurian of Dumfriesshire, under the name of *Discinocaris* (Fig. 2), having a rectangular cervical suture (*c*, *c*, *c*) and *no* dorsal suture.

In 1872,[4] I described a third form of Phyllopod shield, from the Middle Silurian of Hawick, under the name *Aptychopsis*, in which the cervical suture is rectangular (Fig. 3, *c*, *d*, *c*) and a straight dorsal suture *d*, *d*, is also present.

The specimen with which I have now been favoured by Professor G. Dewalque offers a fourth form to this interesting series of Phyllopod shields from the Upper Devonian. It presents us with an elliptical shield (Fig. 4), in which the cervical suture (*c*, *c*, *c*) is semicircular, as in *Peltocaris*, but the dorsal suture is *absent*, as in *Discinocaris*.

FIG. 4.



*Ellipsocaris.*

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[1] Translated from the Annales de la Société Géologique de Belgique, Aug. 1882, T. viii. Mémoires, 4, pp. 45–49.

[2] Quart. Journ. Geol. Soc. vol. xix. p. 88, fig. 1, pl. xxi. fig. 10 (1863).

[3] Quart. Journ. Geol. Soc. vol. xxii. p. 504, pl. xxv. figs. 4–7.

[4] GEOL. MAG. 1872, Vol. IX. p. 564, *id.* 1873, Brit. Assoc. Rep. 1872.

We have then the following characters presented by these Phyllopods:—

*Aptychopsis* (Fig. 3), H. Woodw.
  *a.* Carapace divided along the mesial line by a dorsal suture.
  *b.* Cervical suture rectangular.
*Discinocaris* (Fig. 2), H. Woodw.
  *a.* Carapace entire, *no* dorsal suture.
  *b.* Cervical suture rectangular.
*Peltocaris* (Fig. 1), Salter.
  *a.* Carapace divided along the mesial line by a dorsal suture.
  *b.* Cervical suture semicircular.
*Ellipsocaris* (Fig. 4), genus nov., H. Woodw.
  *a.* Carapace entire, *no* dorsal suture.
  *b.* Cervical suture semicircular.

### *Ellipsocaris Dewalquei*, H. Woodw. gen. and sp. nov.

*Specific Description.*—This interesting specimen was obtained by Professor Dewalque from the base of the "schistes de Frasnes," being the lowest stage of the Famennienne series or Upper Devonian system, at Combláin-la-Tour, in the Province of Liége.

The carapace, which is elliptical in form, is preserved upon the surface of a slab of pale drab-coloured shale, and is 50 millimètres in greatest length, 24 mm. in greatest breadth; the depth of the semicircular cervical suture is 14 mm. and 12 mm. across the cervical portion. The surface is ornamented by numerous fine concentric lines of growth ¼th of a millimètre apart; and by a wide irregular network of reticulations. Between the concentric lines of growth the carapace is also covered with very minute transverse wrinkles or vertical bars often branched and inosculating with each other. This ornamentation closely agrees with that seen upon the valves of *Estheriæ*, notably on those of *Estheria elliptica*, Dunker (see Mon. Pal. Soc. "Fossil *Estheriæ*," by Prof. T. Rupert Jones, 1862, 4to. p. 103–4, pl. iv. fig. 7. See also *Estheria Murchisoniæ*, Jones, *op. cit.* p. 100, pl. iii. fig. 3).

The concentric striæ have frequently been noticed more or less distinctly in all these Phyllopod shields, but this is the first specimen in which I have seen this delicate transverse wrinkling *between* the lines of growth.

I have much pleasure in dedicating this new form under the name of *Ellipsocaris Dewalquei* to my friend Prof. G. Dewalque, its discoverer.

I have examined a large number of head-shields of Phyllopod Crustaceans, from the Silurian, Devonian, and Carboniferous, belonging to the genera *Ceratiocaris*, *Aptychopsis*, *Caryocaris*, *Discinocaris*, and *Peltocaris*; and I find that the absence of the small anterior cephalic portion of the shield, *in front of the cervical suture*, is a common condition in the fossilization of these remains.[1]

As it was to this part of the shield that the muscles of the maxillipedes were attached, when the animal died, or (what is of still more common occurrence) when it exuviated, the carapace would be more likely to be ruptured along this suture than anywhere else, as no doubt the lateral portions of the shield were free, as in the living genus *Apus*, the appendages being all fixed near the head to the anterior portion of the carapace *in front* of the cervical suture.

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[1] Several specimens in the British Museum have this anterior (cephalic) portion of the carapace preserved *in situ*, so that it existed in all without any manner of doubt.

*Ellipsocaris Dewalquei* is not an exception to this rule, being also destitute of the small (cephalic) anterior portion of the shield in front of the cervical suture.[1]

## IV.—Supplement to a Chapter in the History of Meteorites.

By Walter Flight, D.Sc., F.G.S.

(*Continued from p.* 429.)

### Part II.

### 1744, December 10th (before this date). Hizen, Japan.[2]

Dr. Divers has drawn attention to two Japanese meteorites, the property of a gentleman, Mr. Naotora Nabeshima, formerly Daimiyo of Ogi or Koshiro, in the province of Hizen, Japan. They are heirlooms in his family, and used to be in the care of the priests of one of the family temples in Ogi, called Fukuchi- in Gomado. After the revolution the temple was closed. In the family archives there is a record of these stones having been entrusted some years after their fall to a priest named Jishobo, which is dated December 10th, 1744, and his receipt for them is also preserved; they must therefore have fallen about 150 years ago. They were formerly among the offerings annually made in the temple in Ogi to Shokujo (Tanabatatsume) on her festival, the 7th day of the 7th month; they were connected with her worship by the belief that they had fallen from the shores of the Silver River, Heavenly River, or Milky Way, after they had been used by her as weights with which to steady her loom.

The meteorites are somewhat similar in appearance, being angular masses, evidently fragments, irregular quadratic pyramids in shape. The smaller shows a number of small pits or depressions. Faintly marked thin ridges and streaks are to be seen on both stones, radiating with some regularity from about the centre of the base over the basal edges towards the apex; the edges and faces are all rounded, and have the usual very thin, nearly black, coating. The interior is light grey in colour, earthy, porous, somewhat soft, and interspersed with particles of nickel-iron and a few of troilite. The larger stone weighs 5·6 kilog., the smaller 4·6 kilog. The density of the stone was found to be 3·62.

The analysis made by Mr. Shimidzu, one of the students of the Kobu dai Gakko, led to the following results:—

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[1] Since this paper appeared in the Annals of the Geological Society of Belgium in August last I have published descriptions of a series of five new forms of Phyllopod shields from the Upper Devonian of the Eifel under the genera *Cardiocaris* and *Pholadocaris*. See Geol. Mag. 1882, September No., pp. 385-390, Pl. IX.

[2] E. Divers, *Asiatic Soc. Japan*, Tokiyo, Feb. 9th, 1882. *Chemical News*, 1882, xlv. 216.

| | | | |
|---|---|---|---|
| Iron | 15·35 | Iron monoxide, as silicate | 8·64 |
| Nickel, etc. | 1·75 | Lime | 1·94 |
| Manganese | 0·18 | Alumina | 1·89 |
| Tin, etc. | 0·15 | Soda | 0·97 |
| Iron monosulphide | 5·91 | Potash | 0·16 |
| Iron chromite | 0·61 | Manganese monoxide | 0·51 |
| Phosphoric acid | 0·34 | Nickel oxide | 0·30 |
| Silicic acid | 36·75 | | |
| Magnesia | 23·36 | | 99·01 |

Or, arranged mineralogically:—

| | |
|---|---|
| Nickel-iron | 17·43 |
| Troilite | 5·91 |
| Olivine (silicic acid = 13·10) | 32·89 |
| Insoluble silicates (silicic acid = 24·30) | 43·16 |
| Chromite | 0·61 |
| | 100·00 |

If, in accordance with the suggestion of Baron Nordenskjöld,[1] the quantities of oxygen are neglected, it is found that the proportion between the elements in this, and the Orvinio stone (August 31st, 1872), and in the meteorite of Tajima, Japan (February 18th, 1880), are practically identical, thus establishing the interesting fact that meteorites which fell in Japan one hundred and fifty years ago have the same composition as some of those which have fallen recently, both in Japan and on the other side of the globe.

| | Hizen. | | Orvinio.[2] I. | Orvinio.[2] II. | Tajima. |
|---|---|---|---|---|---|
| Iron | 39·70 | 44·7 | | | 43·65 |
| Manganese | 0·86 | | | | — |
| Tin | 0·22 | | | | — |
| Sulphur | 3·27 | | 43·29 | 42·55 | 1·10 |
| Phosphorus | 0·22 | | | | 0·30 |
| Chromium | 0·43 | | | | 2·25 |
| Silicium | 26·06 | | 26·09 | 26·65 | 24·47 |
| Magnesium | 21·30 | | 21·28 | 20·18 | 19·56 |
| Nickel and Cobalt | 3·02 | | 3·16 | 4·71 | 3·86 |
| Calcium | 2·11 | | 2·46 | 2·56 | 2·80 |
| Aluminium | 1·53 | | 1·75 | 1·91 | 1·37 |
| Sodium | 1·09 | | 1·59 | 1·10 | 0·38 |
| Potassium | 0·19 | | 0·38 | 0·34 | 0·26 |
| | 100·00 | | 100·00 | 100·00 | 100·00 |

## 1766, July. Albareto, Modena, Italy.[3]

This meteorite, which is now said to have fallen at Albarello, has been analyzed with the following results:—

| | | | |
|---|---|---|---|
| Iron | 4·332 | Magnesia | 22·773 |
| Nickel | 0·730 | Lime | 2·073 |
| Cobalt | 0·105 | Potash | 0·440 |
| Sulphur | 2·364 | Soda | 1·637 |
| Silicic acid | 35·913 | Loss | 0·840 |
| Iron oxide | 24·313 | | |
| Alumina | 4·479 | | 99·999 |

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[1] Jahrbuch für Mineralogie, 1879, 77.

[2] The cementing substance is I., and the granular matter is II.

[3] P. Maissen, *Gazzetta chimica*, x. 20.

With traces of manganese and chromium. The silicate soluble in hydrochloric acid appeared to be analogous to olivine, and the insoluble silicate to bronzite.

### 1845, May (about dusk).—Barratta Plain, Deniliquin, Australia.[1]

It was stated in an issue of *The Australasian* of the date given below that Mr. H. C. Russell, the Astronomer-Royal, while visiting Deniliquin, succeeded in acquiring for the Sydney Museum the greater part of a meteorite which fell "some years ago" at Barratta Station, 35 miles "below Deniliquin." The stone originally weighed 300lbs., but it had been broken up and fragments had been distributed as curiosities. An announcement appeared in 1874 to the effect that Mr. Liversidge, of the University of Sydney, had made a preliminary examination of its composition. No details seem to have yet appeared.

From a paper since issued by Liversidge it appears that the pieces of stone originally weighed about 2 cwt. The large mass weighs 145 lbs., and this must at first have amounted to from 150 to 157 lbs. Of the two pieces found near the large mass, one weighing about 4 lbs. has been lost, the other weighed 60 to 70 lbs., and was taken to the Editor of the *Pastoral Times* newspaper at Deniliquin, and it also has been lost.

Barratta Station is situated on a vast plain, on which no signs of rocks can be seen; the largest stone to be found weighed 2 oz. A stockman named Jones remembers the fall, which took place about dusk one evening, when a large body like a bush on fire making a loud hissing or roaring noise came from the S.E. and passed overhead. Some fencers who were camped four miles N.W. of the Barratta homestead saw "a thunder and lightning stone" fall on the ground near their camp. It frightened them because they saw it coming directly towards them, but it fell about a quarter of a mile distant. It was found half-buried in the ground, which it had ploughed up for a considerable distance. It was cracked in several places. It is believed to have been, when found, 30 inches in diameter and about 12 inches thick. This would make it one of the largest stones the fall of which has been put on record.

A preliminary chemical examination of the stone by Liversidge shows it to consist of 92 per cent. of silicates of magnesium, iron, and aluminium, and about 8 per cent. of magnetic minerals. The proportion of nickel-iron is small in the extreme, amounting to from 0·063 to 0·086 per cent., and cobalt is stated to be entirely absent. On the outside it has a blackish fused crust and the outer layers appear to possess a strongly laminated structure to the depth of from three-quarters of an inch to one inch. Below this the stone is much more compact, and granular, inclosing numerous spheroidal bodies. Under the microscope small grains of green mineral resembling olivine are to be seen, also particles of a yellow mineral which passes into brown. The specific gravity of the outer layer is 3·382. The inner part of the stone has a distinctly chondritic structure; some of the chondra are comparatively large, from one-sixteenth to one-eighth of an inch across, and a few are a little larger. The specific gravity of this portion of the stone is 3·503. Mr. Russell, who took the density of the large block, makes it 3·387. The grey granules were submitted to a superficial examination and showed the reactions of bronzite.

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[1] *The Australasian*, April 22nd, 1871.—*Nature*, iv. (1871), 212.—See also *The Journal of Science*, January, 1874, 123.—The Deniliquin or Barratta Meteorite. By Archibald Liversidge. 1875. Sydney: T. Richards, Government Printer.

I have to thank Prof. Liversidge for sending me several microscopic sections of this very important meteorite.

### The Siderolite of Rittersgrün.—Found 1833.[1]

The examination by Dr. Clemens Winkler of the siderolite of Rittersgrün, Saxony, shows it to accord closely in composition with the siderolite of Breitenbach in Bohemia, examined some years since (1871) in the Laboratory of the Mineral Department of the British Museum; and to strengthen the view expressed at the time that these bodies, as well as the meteorite of Steinbach in Erzgebirge were probably members of the same fall, possibly of the "Eisenregen" reported on by Sartorius (died 1609) as having fallen "im Meissnischen" at Whitsuntide, 1164.

The Rittersgrün meteorite was found in 1833 by a workman employed in clearing the forest, and offered for sale as old iron to a smith, but without success; but in 1861 it came to the notice of the lamented Professor Breithaupt, and was secured for the mineral collection of the Bergakademie, of Freiberg. Its mean diameter is 0·43 metre, and its weight 86·5 kilogrammes. It has recently been sawn through in Vienna, a troublesome and costly labour extending over two months. An excellent chromo-lithograph of the surface thus exposed was prepared by Professor Weisbach, in 1876, and published with a few notes.[2]

The meshwork of nickel-iron of the siderolite incloses the following minerals: troilite, asmanite, bronzite, and chromite; the metallic portion constitutes about 51·06 per cent., and the non-metallic ingredients about 48·94 per cent. of the stone. The nickel-iron contains:—

| Fe | Ni | Co | Ca | P | S | Si | C | Asmanite. | |
|---|---|---|---|---|---|---|---|---|---|
| 89·990 | 9·740 | 0·230 | 0·035 | 0·150 | 0·011 | 0·066 | Trace | 0·056 | = 100·278 |

which constituents may be arranged as follows:—

| | |
|---|---|
| Nickel-iron $Fe_9Ni$ ... ... ... ... ... ... ... | 98·995 |
| Iron-nickel phosphide $(FeNi)_4P$ .. ... ... ... | 0·293 |
| Iron phosphide $Fe_2P$ .. ... ... ... ... ... ... | 0·539 |
| Iron silicide $Fe_2Si$ ... ... ... ... ... ... ... | 0·330 |
| Iron sulphide FeS ... ... ... ... ... ... ... | 0·030 |
| Iron carbide ... ... ... ... ... ... ... ... | Trace |
| Copper ... ... ... ... ... ... ... ... ... | 0·035 |
| Asmanite ... ... ... ... ... ... ... ... ... | 0·056 |
| | 100·278 |

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[1] C. Winkler, *Nova Acta der K. Leop. Carol., Deut. Akad. der Naturforscher*, xl. Nr. 8, 333. Halle, 1878.

[2] Der Eisenmeteorit von Rittersgrün im Sachsischen Erzgebirge. By A. W. 1876. Freiberg Kön. Bergakad.

The iron sulphide, regarded as troilite, when in the form of pieces, is not acted upon by the magnet, and when in the form of powder, but feebly so. The ratios of iron to sulphur in troilite or iron monosulphide, and in magnetic pyrites, differ in so small a degree that the analytical results do not always put the question at rest. It is moreover a question whether the meteoric sulphide, associated as it is with nickel-iron, does not actually contain some of the metal as an ingredient. The numbers obtained in these analyses are as follow:—

| | Calculated | Found | | |
|---|---|---|---|---|
| | | I. | II. | III. |
| Iron ... ... | 63·63 | 65·87 | 63·58 | 63·00 |
| Nickel ... ... | — | 1·40 | — | 1·02 |
| Sulphur ... | 36·37 | 34·27 | 36·42 | 35·27 |
| Silicic acid ... | — | — | — | 0·67 |
| | 100·00 | 101·54 | 100·00 | 99·96 |

The asmanite appears to have the density of 2·274–2·278, and the following composition:—

| $SiO^2$ | $Fe_2O_3$ | CaO and MgO. | Loss on Ignition. | | |
|---|---|---|---|---|---|
| 95·77[1] | 3·16 | Trace | 1·07 | = | 100·00 |
| 97·84 | 1·65 | ,, | 1·01 | = | 100·50 |

As regards the crystalline form of this mineral, Weisbach considers that the recent researches of Schuster and of Von Lasaulx have placed almost beyond any doubt the identity of tridymite and asmanite. It occurred to the author that the relative solubility of tridymite and asmanite in potash solution should be determined, and in as nearly parallel experiments as it was possible to devise, it was found that of tridymite from Siebenbürgen 49·63 parts, and of asmanite from Rittersgrün 43·88 parts, were dissolved.

The bronzite, the most prominent of the non-metallic minerals, was obtained in a pure form with comparative ease. It is but slightly affected by the blowpipe, and is not acted upon by acids with the exception of hydrogen fluoride. Its specific gravity is 3·310. It possesses the following composition:—

| | I. | II. | III. |
|---|---|---|---|
| Silicic acid ... .. | 57·27 ... | 56·56 ... | 56·56 |
| Alumina ... ... | 2·28 ... | 2·05 ... | 2·04 |
| Iron protoxide ... | 10·99 ... | 10·74 ... | 10·09 |
| Manganese protoxide | 0·41 ... | 0·42 ... | 0·55 |
| Magnesia ... ... | 24·78 ... | 25·13 ... | 25·59 |
| Lime ... ... ... | 1·77 ... | 2·52 ... | 1·66 |
| Soda ... ... ... | not determined ... | 1·43 ... | 1·43 |
| Chromite ... ... | 0·94 ... | 0·98 ... | 0·98 |
| | 98·44 | 99·83 | 98·90 |

No trace of olivine was met with in this material.

Heated *in vacuo* the substance of the meteorite lost 0·23 per cent. of its weight, and the gas evolved took fire, but was so small in quantity that it could not be further examined. The meteorite possesses the "crust of fusion" in a fully developed form; it is of about the same thickness as a sheet of paper, and close under it are found the mixture of the minerals troilite, asmanite, and bronzite, of an unaltered light brown colour, although they turn deep black when raised to a temperature slightly above that at which lead melts. The author's pages conclude with some considerations on the probable temperatures of meteorites in their passage through our atmosphere.

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[1] By difference.

### 1840.—De Calb Co., Caryfort, Tennessee.[1]

Brezina points out that in Tschermak's Catalogue[2] this iron is described as compact, and in Rose's *Beschreibung und Eintheilung* it is shown to resemble that from Babb's Mill. A fine section, acquired from Professor L. Smith, shows it to be rightly placed near the irons of Arva and Sarepta. Almost every band of kamacite, 1·5 to 3 millimètres across, carries a bar of porous schreibersite; band-iron and interstitial iron are sparsely present, and of a dull grey colour. Two inclosed pieces of troilite, from 3 to 4 mm. diameter, are surrounded by schreibersite from 1·5 to 2 mm. thick, and around this is an irregular shell of beam-iron.

### 1841, September 6th.—St. Christophe-la-Chartreuse, Commune de Roche-Servières, Vendée.[3]

The fall of this stone, which was accompanied by a double detonation resembling thunder and a luminous appearance, took place in the vineyards of St. Christophe at the above date. It created quite a panic in the surrounding country; on the first day none of the peasants would approach it; one could only look with fear in the direction where it lay, it was said; but on the following day a young man, who was escorted to the spot, found it out and brought it away with him.

The stone weighs 5·500 kilogrammes, and is in the hands of a proprietor who was neither disposed to communicate any information respecting it, nor to allow any fragments to be removed. M. Daubrée has therefore to content himself with registering its existence, which up to the present time has not been placed on record.

### Found about 1850.—Pittsburg, Alleghany Co., Pennsylvania.[4]

This large mass of meteoric iron, weighing 132 kilog., was turned up by a plough at Pittsburg. It was briefly described at the time by Silliman, and has now been analyzed by Dr. Genth. The specific gravity appears to be 7·741; and the chemical composition of a somewhat oxidized specimen was found to be

| | |
|---|---|
| Iron | 92·809 |
| Nickel | 4·665 |
| Cobalt | 0·395 |
| Copper | 0·034 |
| Manganese | 0·141 |
| Sulphur | 0·037 |
| Phosphorus | 0·251 |
| | 98·332 |

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[1] A. Brezina, *Sitzber. Akad. Wiss.* 1880, lxxxii. Oct.-Heft.

[2] *Mineralog. Mitth.* for 1872, 165.

[3] G. A. Daubrée, *Compt. rend.*, 1880, xci. 30.

[4] F. A. Genth, *Amer. Journ. Sc.* 1876, vol. xii. p. 72. *Report of Geological Survey of Pennsylvania*, 1875.

The phosphorus corresponds with about 1·8 per cent. of schreibersite. The iron, when etched, exhibits Wiedmannstättian figures, and the presence of minute crystals of a phosphide could be recognized on the surface of the section.

(*To be continued in our next Number.*)

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## V.—NOTES ON THE BURE VALLEY BEDS AND THE WESTLETON BEDS.

By HORACE B. WOODWARD, F.G.S.;
of the Geological Survey of England.[1]

IN two papers, read in 1881, before the meeting of the British Association at York, Prof. Prestwich has discussed the structure and distribution of certain deposits which he has called "The Mundesley and Westleton Beds." In his opinion they occupy an horizon "between the Chillesford Beds and the Lower Boulder-clay."

My work on the Geological Survey in Norfolk has, however, led me to conclusions that differ in important particulars from those of Prof. Prestwich, and chiefly in the correlation of beds in several localities. As his papers have at present been published only in brief abstract, it is not possible to criticize them with justice to the author; but as a year has now elapsed since the conclusions were made known, I may be pardoned for submitting my own views for discussion at the present time.

All who have paid attention to the geological literature of Norfolk, know that the nomenclature of the Pliocene and Post-Pliocene deposits is in a most confused and deplorable condition, chiefly on account of the many subdivisions made in the strata, and the difficulty of correlating with certainty those made in one place with those made in another.

In papers read before the Norwich Geological Society in 1878,[2] I endeavoured to convince my hearers that in Norfolk, at any rate, the introduction of the words "Chillesford Clay" had been the root of nearly all the evil in the shape of confused or complicated classification. Coming into Norfolk (in 1875) from a county where the thickness of some of the rocks was reckoned by thousands of feet, I may perhaps have contemplated with too little respect divisions that dwindled into inches. No less than five subdivisions had been made in the Pliocene Beds, where they reached about 30 feet in thickness: and of these nearly all had two or three names. But most distressing of all was the indiscriminate identification, by some observers, of the famous Chillesford Clay, with any micaceous and laminated clay-seam that was developed in the series of Pliocene (Crag) beds between the Chalk and Glacial Drift. So false-bedded is this series that no dependence can be placed on these identifications. Seams and "jambs" of laminated clay occur at all horizons in the Norwich Crag Series. Such is conspicuously the case in the Pliocene beds on the Norfolk coast, where Messrs. Wood and Harmer have indeed failed to identify this Chillesford Clay, although it has been detected there by Mr. Gunn and Mr. J. H. Blake. Even

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[1] Communicated by permission of the Director-General of the Geological Survey

[2] Proc. Norwich Geol. Soc. vol. i. pp. 22, 49.

Prof. Prestwich, while applying the name to clay-beds in various places, observes that "In Norfolk, however, as the sands and shingle overlying the Chillesford Clay become interstratified with beds of laminated clay very similar in appearance to the Chillesford Clay, it might be a question whether the bed which I have referred to that deposit in Norfolk belongs to it, or whether the Chillesford Clay is represented by the Laminated Clays of Mr. Gunn."[1] This questionable position is after all the safest one to take up; but as an instance of the intricate nature of the case, I may mention that on one occasion of a meeting in Norfolk, when the discussion about these clay-beds waxed warm, a distinguished Norfolk geologist exclaimed that he thought after all that the Chillesford Clay at Chillesford was *not* the Chillesford Clay! So much for this interesting deposit.

The Westleton beds, which Professor Prestwich described in 1870, from the village of Westleton, between Yoxford and Dunwich in Suffolk, attain at this typical locality "a thickness of from 30 to 40 feet, and consist of a series of stratified beds of well-rounded flint-pebbles imbedded in white sand, and with two or three subordinate beds of light-coloured clay," looking, as Prof. Prestwich remarked, "more like the pebble-beds of Blackheath than any other beds in the Eastern counties."[2] Continuations of these Westleton Beds have been traced to Southwold, Henham Park, Halesworth, and other places in Suffolk—localities which I believe are rarely fossiliferous, and yield no distinctive species. In Norfolk, however, the Westleton Beds have been correlated with certain deposits grouped as "Bure Valley Beds" by Messrs. Wood and Harmer, described in 1866 by the former geologist under that name,[3] and known also as the "Pebbly Sands and Pebble Beds." When, therefore, Prof. Prestwich's paper was published in 1871, Messrs. Wood and Harmer opposed the introduction of the term "Westleton Beds," and expressed their indignation in a footnote on pp. xv and xvi of the Introduction to the Supplement to the 'Crag Mollusca' (1872).

The Bure Valley Beds comprise most of the pebbly sands and gravels that overlie the Chalk and underlie the Lower Glacial Brickearth (Contorted Drift, etc.), in the valley of the river Bure. They are characterized by *Tellina Balthica*, and chiefly on account of the presence of this shell, the Bure Valley Beds were separated from the Norwich Crag by Messrs. Wood and Harmer, and grouped by them as Lower Glacial. The typical Bure Valley Beds were described by them at Belaugh, Wroxham, Crostwick, etc.; and only at Horstead, Coltishall, and Burgh-next-Aylsham, were fossiliferous sections of the Norwich Crag (Chillesford Beds) recognized, by these authorities, in the Bure Valley. During my geological survey of the district I failed to find any satisfactory separating line between the so-called Bure Valley Beds and the Norwich Crag, and

[1] Quart. Journ. Geol. Soc. vol. xxvii. p. 470.

[2] Quart. Journ. Geol. Soc. vol. xxvii. p. 461.

[3] Quart. Journ. Geol. Soc. vol. xxii. p. 547.

I have united them under the more comprehensive name of the "Norwich Crag Series."[1]

The grounds on which Messrs. Wood and Harmer separated the Bure Valley Crag from the Norwich Crag have proved to be unsound. The Bure Valley Crag is palæontologically identical with the Weybourn Crag, as they originally pointed out. Both beds contain the *Tellina Balthica.* But as my colleague Mr. C. Reid has shown, the Weybourn zone is to be traced at the *base* of the Forest Bed Series, at Sherringham and other places; whereas another bed, at a higher horizon, since called the "*Leda-myalis* bed" by Mr. Reid, was also correlated by Messrs. Wood and Harmer with the Bure Valley Beds.[2] Thus we have a fossiliferous zone at the top, and another at the base of the "Forest Bed Series," both of which have been called the Bure Valley Beds; and this is the reason why some observers have stated that the Norwich Crag overlies the Forest Bed of Cromer, while others have maintained that the Crag underlies it. The true fossiliferous Bure Valley Zone, however, as just stated, occurs at the base of the Forest Bed Series, and is represented by the Weybourn Crag. The *Tellina Balthica* thus occurs *beneath* beds which Messrs. Wood and Harmer have grouped as "Pre-glacial," and their argument that this shell is confined to Glacial and more recent deposits loses all weight.[3] Their argument, too, that the Bure Valley Beds are in places interbedded with the Cromer Till, likewise disappears, when it is seen that the Bure Valley Beds occupy this lower horizon on the coast. For the same reason, also, the Mundesley and Westleton Beds, identified by Prof. Prestwich on the Cromer coast, are not the same as the Bure Valley Beds inland.

In his address to the Norwich Geological Society (1880) my colleague Mr. J. H. Blake has retained the use of the term "Bure Valley Beds" for the upper zone on the coast before mentioned—the *Leda-myalis* bed.[4] This is unfortunate, especially as he admits the Weybourn Crag (the Bure Valley Beds proper) to be part of the Norwich Crag. Amid such confusion of terms I should fear in the end that (as with the Chillesford Clay), there would after all be no Bure Valley Beds in the Bure Valley!

Another reason given by Messrs. Wood and Harmer for separating the Bure Valley Beds from the true Crag, was that at Henham and other places in Suffolk, these beds rested unconformably upon the Chillesford Beds beneath. We now come to the critical point. The question arises, Are the Westleton Beds of Westleton the same as the Bure Valley Beds of the Bure Valley? I do not believe they are.

The Bure Valley Beds may be traced southwards from the Bure Valley, across the valley of the Yare into the valley of its little tributary the Chet, at Sizeland, Mundham St. Peter, and Burgh

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[1] Geology of England and Wales, 1876; Geology of the Country around Norwich (Geol. Survey), 1881.

[2] See GEOL. MAG. Dec. II. Vol. IV. p. 300, Vol. VII. p. 548, Vol. VIII. p. 382.

[3] Proc. Norwich Geol. Soc. vol. i. pp. 48, 142.

[4] Proc. Norwich Geol. Soc. vol. i. pp. 150, 159; see also C. Reid, GEOL. MAG. Dec. II. Vol. VIII. p. 382.

Apton, west of Loddon. The beds consist of false-bedded pebble-gravel and sand with seams of laminated micaceous sand and clay, streaks of clay, and clay-balls; altogether twenty feet and more in thickness.[1] Like most other formations they present a facies more easily recognized than described. The sand is sometimes white, and often of a bright orange-colour.

The Westleton Beds are to be traced northwards from Halesworth to Thorpe-next-Haddiscoe, east of Loddon. Probably no one would dispute this correlation. At Thorpe-next-Haddiscoe we find 15 to 20 feet of buff sand and shingle—dovetailing one into the other. The general aspect of these Westleton Beds and of the Bure Valley Beds is quite distinct. Until, however, the mapping of the area was finished, I was not satisfied that the beds were on different horizons. The Westleton shingle was traced in several pits in the parishes of Heckingham and Norton Subcourse. Further west, at Hardley, I traced this pebble-gravel in connexion with the Lower Glacial brickearth, and came to the conclusion that it was the newer deposit, overlying the brickearth; thus making the Westleton Beds in this neighbourhood of the same age as the "Middle Glacial" Sands of Messrs. Wood and Harmer. At Hardley Hall the pebble-gravel was shown in a pit, underlain to the north-east by clay, which I take to be the Lower Glacial brickearth, as this deposit was again displayed in a pit about a mile to the west, where, in its characteristic form of the "Contorted Drift" or Stony loam, it rises as a boss into the overlying sand and gravel.

At Chedgrave, again, the pebble-gravel (Westleton Beds) was well exposed, passing in short distances into sand, and these beds evidently overlaid the Lower Glacial brickearth, which was shown in pits by the Manor House. Higher up the valley the Bure Valley Beds (Norwich Crag Series) were exposed, beneath the Glacial brickearth.

Although we have not the actual sections to demonstrate the succession of the beds as here maintained, the evidence obtained by mapping (in the form of the ground, etc.), is sufficient to justify a confident assertion that such is the structure. Only by these means can minute correlation be carried on from one tract to another in the variable deposits of Norfolk. The published longitudinal sections of the country taken inland, it must always be remembered, while clearly expressing the views of the authors, are not necessarily statements of facts observed, for very seldom are pits opened deep enough to furnish all the desired information.[2]

The evidence in the neighbourhood of Loddon shows that the pebble-gravel of Haddiscoe is Glacial, and distinct from the Bure Valley Beds which are connected with the Crag. From this it may be inferred that the similar beds of Halesworth, Henham, and

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[1] See Memoir on the Geology of the Country around Norwich (Geol. Survey), pp. 85, 106.

[2] See on this subject, the remarks of Messrs. Wood and Harmer, Quart Journ. Geol. Soc. vol. xxxiii. pp. 84-86, and their Section across the Ket (or Chet) Valley, *Ibid.* p. 93.

Westleton are not Bure Valley Beds, but that they also are of Glacial age. This supposition is sufficiently startling to need a little further support, if possible.

I may here quote a passage written by Mr. Harmer in 1869. He says, "The only doubt felt by Mr. Wood and himself in connexion with the beds of the Crag series in Norfolk is, whether or not the pebbly sands of Belaugh and Weybourne are identical with the pebbly sands and pebble beds which overlie the Chillesford Clay in the neighbourhood of Norwich, of Loddon, of Halesworth, and of Beccles, or whether they do not form a still later deposit."[1] These remarks show there was room for doubt. The uncertainties of geological correlation are, however, borne out in a remarkable way as I have elsewhere mentioned.[2] In the summer of 1876 I had the pleasure of accompanying Mr. J. H. Blake in an excursion to Westleton and Dunwich. We then satisfied ourselves that the Westleton shingle was the same as that exposed at the top of the Dunwich Cliff. Mr. Whitaker has informed me that he has come to the same conclusion. There can indeed be no question about the matter, when the beds are traced directly from one spot to the other.

The shingle at Westleton was originally grouped as Lower Glacial (equivalent to their Bure Valley Beds) and that at Dunwich as Post-Glacial[3] (Plateau gravel) by Messrs. Wood and Harmer; while the former was grouped as Pre-glacial, and the latter as Inter-glacial by Prof. Prestwich. Thus the Dunwich pebble-gravel was regarded by Prof. Prestwich as on the same horizon as the "Middle Glacial" sands, which he called Inter-glacial Boulder sands and gravels. The Dunwich shingle is indeed a portion of the main mass of beds which constitute the "Middle Glacial" formation of Messrs. Wood and Harmer. This agrees with the evidence obtained near Loddon.

Hence not only are the Westleton Beds distinct from the Bure Valley Beds (Norwich Crag Series), but they must be distinct from the Mundesley Beds which underlie the Lower Glacial Drift on the Norfolk coast.

I should not omit to mention that in places, as at Sotterley, between Beccles and Southwold, Messrs. Wood and Harmer have detected pebble-gravel beneath the Lower Glacial Brickearth—this, however, may belong to the Norwich Crag Series. Moreover, there are beds of laminated brickearth, at Rockland, Surlingham, Diss, and other places in Norfolk, that overlie the sands and gravels grouped as Middle Glacial, and are directly overlain by the Chalky Boulder Clay.

For my own part, under the term "Lower Glacial Drift," I would include not only the Cromer Till and Contorted Drift, but also the "Middle Glacial," as I regard them as intimately connected: hence the Westleton Beds would be Lower Glacial, the Mundesley Beds would come in the debateable ground called Pre-glacial, the Bure Valley Beds are Pliocene.

[1] Geol. Mag. Vol. VI. p. 234. [2] Proc. Norwich Geol. Soc. vol. i. p. 47.

[3] This was owing to the dovetailing of a mass of Chalky Boulder Clay.

P.S.—I would add that the term "Pre-glacial," though sometimes a convenient word to use, is very objectionable in any system of classification. The "Pre-glacial" beds on the Norfolk coast are stratigraphically connected with the Pliocene strata, and although they present some palæontological features that serve to connect the Crag deposits (Pliocene) with the Glacial Drift (Pleistocene), I agree with my colleague, Mr. Reid, in grouping the Norfolk Pre-glacial or Forest Bed Series with the Pliocene rather than with the Pleistocene deposits.[1]

## VI.—ON THE CAUSE OF THE DEPRESSION AND RE-ELEVATION OF THE LAND DURING THE GLACIAL PERIOD.

By THOMAS F. JAMIESON, F.G.S.

(*Concluded from p.* 407.)

### APPLICATION OF THE HYPOTHESIS—ENGLAND.

In England the ice seems to have been heaviest in Wales and the N.W., and lightest on the East and S.E., where it appears to have thinned off altogether, and the evidence of depression corresponds with this. If we draw a line from Dover to Anglesea, we find proof of great submergence in Wales, decreasing to zero as we approach the English Channel. And Prof. Hughes of Cambridge, in a recent paper "On the Evidence of the Later Movements of Elevation and Depression in the British Isles," read before the Victoria Institute, says: "As we trace these movements north to the borders of the mountains, we find evidence of greater sinking and greater elevation." . . . . "Along the mountain chains the movements were always greater." Then as to the order in which the movements took place, we find the following statements:—"This point is clear that after glacial times the land went down below the sea, and then the ice was lifted and melted off. After that the land began to rise." In like manner Professor Ramsay writes: 'Of this I am certain that probably during and certainly after the largest extension of glacier-ice, the land underwent a process of submersion" (Phys. Geol. of Gt. Britain, 5th ed. p. 411). "After what seems to have been a long period of partial submergence, the country gradually rose again" (*ib.* p. 419).

It is impossible not to see how closely this order of events corresponds with the hypothesis I am advocating, and this same order seems to have been the rule in all glaciated regions. The land is first heavily loaded with ice, then it goes down and the ice clears off, after which the land comes up again. The chief submergence or depression seems to have always followed hard upon the great glaciation of the country, and the disappearance of the ice which then took place is followed by the land rising again. The conclusion seems obvious.

In Ireland the Rev. Maxwell Close and Professor Hull require the same train of events. First a great covering of ice, then a submergence beneath the sea, during which the glacier vanishes, and after that the land comes up again.

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[1] Mr. Reid's Memoir on the Geology of the Country around Cromer (in the press) will give full particulars of these deposits. See also Prof. W. Boyd Dawkins, Address to Department of Anthropology, Brit. Assoc. 1882.

## NORTH AMERICA.

The lower part of the Mississippi basin, as described by Hilgard (American Journ. of Science, vol. xlvii. p. 77, 1869), seems to afford good evidence of a depression having taken place in the northern part of that valley after the commencement of the Glacial Period. The lowest bed he calls the *Orange Sand*, which he says bears evidence of having been formed by a rapid current of water flowing down the valley. The mineral character of the pebbles which it contains shows that the material came from the northward. Above the Orange Sand there are swamp and lagoon deposits, and heavy beds of fine silt or loess, indicating, according to Hilgard, a period of slow secular subsidence. In these beds there are no marine fossils; the organic remains are of terrestrial and freshwater animals. Now these features are quite intelligible on the supposition that the weight of the great glacier which lay on the region to the northward caused a slow and gradual depression of the area beneath it, and thus lowered the gradient of the river and led to a more sluggish flow of the water, so that it was no longer able to carry along gravel and pebbles, but stagnated in pools and marshes. Lastly the denudation of the Loess shows that when the ice disappeared, the northern area rose again, but not to so great a height as it had before, during the time of the Orange Sand.

American geologists also seem to think that it is impossible to account for the freshwater drift and terraces along the great lakes without supposing a depression of that region to have taken place after the commencement of the Glacial period; a depression which seems to have been greatest on the northern side of the lakes and to have diminished to the south of them.[1] It is evident Dr. Croll's theory can give us no help here nor in the Mississippi Valley, for there is no trace of the presence of the sea.

Along the borders of the lakes there are terraces of finely stratified clay and sand, many of which lie at a much greater height than the wide stretch of low ground to the southward, which divides these lake-basins from the head-waters of the Mississippi and Ohio. The country from Lake Erie round the southern border of Lake Michigan consists of a wide extent of low land or plain opening into the basin of the Mississippi and Ohio, so that were we to dam up the present outlet of these lakes to the eastward, and raise the water to the level of these upper terraces, it would flow freely away by these wide openings down to the Gulf of Mexico. At first it was supposed by Desor, and other geologists who led the way in exploring the district, that these beds were marine, and that the waters of the Gulf of Mexico had formerly extended up the valley of the Mississippi into the heart of the continent; but the progress of investigation by Mr. Whittlesey and others soon overthrew this notion, for no recent marine fossils could anywhere be found, and all the organic remains that were detected turned out to be land and freshwater shells, together with some bits of trees and plants. It is also manifest that had the warm waters of the Gulf penetrated so far into the interior of the Continent the effect would have been to carry such an amount of heat thither that glacial conditions would have been impossible. American geologists are now agreed that the glacier at one time filled the basins of all the great lakes and even stretched a good way beyond them, while Dr. Newberry and others suppose that as the ice melted and shrank back to the north a body of freshwater formed in front of it and filled the area that the ice abandoned; in this lake which bathed the southern margin of the glacier the sediment was deposited that now forms the stratified clay and sand. Such a sheet of water would at present escape down the St. Lawrence and out by the Mohawk and Hudson valleys to the Atlantic; but during the Glacial period its exit in that direction appears to have been barred by the ice that lay across its path and blocked all the outlet to the north and east. It seems probable that the thicker ice which lay to the north and north-east would continue to fill up that outlet for a long time after the thinner ice melted away from the southern shores of the western lakes; and it has been ascertained that as the lake was gradually lowered, its waters found their way out into the valleys of the Mississippi, the Wabash, and the Ohio by channels which can still be traced with the greatest clearness. That the ice was thicker to the east of the lakes is proved by the fact that the glacier moved along the basins of Lake Ontario and Lake Erie from N.E. to S.W., as appears from the ice-marks on the rocks. On this point the American geologists seem to have no doubt.[1] This shows that the glacier must have been heavier at the eastern extremity of Lake Ontario than it was at the west end.

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[1] Dana says the terraces on the north side of Lake Ontario are very much higher than those on the south side. See his "Manual of Geology," 2nd ed. p. 552.

It is clear, therefore, that if a lake existed, such as Dr. Newberry maintains, its escape to the southward must have been prevented by the relative level of the land in that direction having been higher than it is now. In other words, the northern area must have been relatively lower. But this northern area was just that which was longest occupied by the ice, and as it gradually melted away the land seems to have regained, to some degree, its former height. My idea therefore is that the immense weight of ice, which accumulated over the basin of the lakes and the region to the north and east, occasioned a depression of the area on which it lay, and, after this weight was taken off by the ice melting, the depressed tract slowly rose again. I think, however, that the recovery of level was not complete, and that the Canadian ridge has never regained the height it had at the commencement of the Glacial period. Dana in the 2nd edition of his Manual expressly says that the amount of depression increased northward so that the beds of rivers flowing southward had a diminished slope.

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[1] See Newberry's Surface Geology of Ohio, p. 76; also, G. J. Hinde in the Canadian Journ. for April, 1877; and Dana's Manual, 2nd edition, p. 536.

The marine beds which occur at Lake Champlain and along the valley of the St. Lawrence have not been traced into the basin of Lake Ontario, although they reach to Kingston, which is close to its eastern extremity. Now as the present level of Ontario is 230 feet above the sea, and the highest marine beds at Montreal reach up to 470, it is evident that in the present configuration of the country, a sea reaching this level at Montreal would extend into and cover all Lake Ontario. But the strata around Lake Ontario are lacustrine, and so far as hitherto explored have yielded nothing but land and freshwater fossils, and not a trace of the marine shells have anywhere been got which are so common in the sands and clays of Montreal and Quebec. We are therefore driven to the conclusion that the sea water somehow did not gain access to the area of the great lakes, or, if it did, the deposits left by it have since been removed. But we have seen that other facts point to the conclusion that the ice must have vanished from the lake region long before it disappeared from the valley of the St. Lawrence: so that if the depression was caused by ice, the lake region would be sooner relieved from pressure, and would regain its height long before the St. Lawrence district did so. The submergence of the latter would therefore take place after the shores of Lake Ontario had risen, and the sea-water would consequently not extend into the lake basin; moreover the ice, as we have seen, being heaviest to the east of the lake, would cause a greater depression in that direction. This curious circumstance therefore harmonizes with the theory I am advocating.

It is perfectly plain that the supposed action of an ice-cap affecting the centre of gravity of the earth, and draining the ocean waters northwards, is a theory that affords no explanation of these singular features in the surface geology of the great lake district of America and of the Mississippi basin, because it is not a question of submergence beneath the sea that we have to answer in these regions. It is a sinking and rising of the land, not of the sea, that we have to account for.

### THE LOESS BEDS.

Movements of depression and elevation caused by the presence and disappearance of the ice would also help to explain the formation of the Loess beds of the Rhine, Danube, and other rivers.

In reference to the Loess of the Rhine, Sir Charles Lyell says: "It seems necessary to suppose first a time when it slowly accumulated; and secondly, a later period, when large portions of it were removed, or when the original valley which had been partially filled up with it, was re-excavated. Such changes may have been brought about by a great movement of oscillation, consisting first of a general depression of the land, and then of a gradual re-elevation of the same. The amount of continental depression which first took place in the interior must be imagined to have exceeded that of the region near the sea, in which case the higher part of the great valley would have its alluvial plain gradually raised by an accumulation of sediment, which would only cease when the subsidence of the land was at an end. If the direction of the movement was then reversed, and, during the re-elevation of the continent, the inland region nearest the mountains should rise more rapidly than that near the coast, the river would acquire a denuding power sufficient to enable it to sweep away gradually nearly all the loam and gravel with which parts of its basin had been filled up."[1]

Now, the Rhine and the Danube both take their rise in the Alps and high mountains of Central Europe, and we know that during the formation of the Loess these mountains were deeply covered with ice, which spread over Switzerland and the neighbouring regions. We have, therefore, only to suppose that this ice depressed the mountain tract on which it rested, and thus lessened the slope of the upper valleys of the Rhine and Danube, just as it did in the case of the Mississippi. The consequence would be that these rivers would no longer be able to hurry along gravel and pebbles as they did before, but would have to slacken speed and expand into pools and marshes, wherein the Loess would be deposited. Then, after the ice melted, the mountain area would rise again, and set the rivers aflowing down the valleys, and make them out into the old beds of silt just as Lyell describes.

Judging from the accounts of Lyell, Belt, Daubree, and others, it would seem that the valley of the Rhine had been excavated to more than its present depth in times previous to the deposition of the Loess, for it lies upon the top of strata of gravel which occupy the bed of the river, and contain the remains of an older fauna.

Mr. Archibald Geikie made a good suggestion in reference to the Rhenish Loess. He supposed that the advance of the Scandinavian glacier might have blocked up the mouth of the river and thus dammed the water into a lake in which the Loess would then be deposited. But this would not account for the Danubian Loess; moreover, the Loess does not seem to be exactly a lacustrine deposit, for its surface does not form a horizontal line but slopes somewhat down the valley, and the shells found in it do not, according to Lyell, imply the permanent sojourn of a body of freshwater on the spot, the most aquatic of them, the *Succinea elongata,* being an inhabitant of marshes and wet grassy meadows.

It seems likely that there might be not only a slight sinking of the ice-covered tract, but likewise a tendency to bulge up in the region which lay immediately beyond this area of depression; just as we sometimes see in the advance of a railway embankment, which not only depresses the soil beneath it, but also causes the ground to swell up farther off. The ice, therefore, by depressing the upper part of the valleys and raising their mouths, would check the flow of the rivers and lead to stagnation in the region between, where fine mud or loess would therefore accumulate. The material of the loess may have been derived from the fine mud suspended in the water flowing from the glaciers, or partly also, as suggested by Baron Richthofen, from dust carried by the wind.

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[1] Students' Elements of Geology, 2nd ed. p. 133. See also Lyell's Antiquity of Man, chap. xvi. for fuller details regarding the Loess.

## GREENLAND.

In Western Greenland, according to Capt. Graah and Dr. Pingel,[1] there is evidence of a depression of the land having been going on for the last four centuries, and some think the land-ice has been on the increase during the same period. Adhemar in his book maintained that, in accordance with his theory, the temperature of the northern hemisphere was highest about the year 1248, and has been on the decline since then. He also contended that the Arctic ice has been increasing during the same period, and the Antarctic diminishing. It would be indeed an interesting coincidence were it actually the fact that in Greenland an increase of the ice in modern times has been accompanied by a subsidence of the land. It would appear that the Greenlanders have long had an idea that the ice is increasing. The Danish naturalist, Fabricius, who flourished in the latter part of the eighteenth century, states that the land-ice was advancing every year; and so rapid was its progress that Greenlanders, then alive, remember their fathers hunting reindeer among naked mountains, which had become completely covered with ice; but that it was in the valleys the increase was greatest.

The facts detailed by Dr. R. Brown seem to leave no room for doubt as to the subsidence of part of the coast in recent times; and as regards the increase of the ice, we have not only the opinions and traditions of the inhabitants, but also the testimony of Nordenskiöld, who tells us that there can be no doubt that in many parts of North Greenland the inland ice is certainly gaining ground.[2] In 1850 Dr. Rink mapped the south side of Umanak Fjord (about lat. 71°), showing the extent of the glaciers in that locality, and recording their exact distance from the sea. In 1875 Mr. Helland visited six of these glaciers, and found that since 1850 two of them had advanced considerably, and one had retreated. In regard to the other three there would appear to have been little variation (Quart. Journ. Geol. Soc. vol. xxxiii. p. 154, 1877).

## FJORD LATITUDES AND THE SKÄRGÅRD.

It is worthy of remark that in all Fjord latitudes there are chains of rocks and islands along the coast lying a little outside the main mass of land. In Norway this is called the "Skärgård." The same feature is seen on the west coast of Greenland, and very notably in British Columbia and Patagonia, and also to some extent on the west coast of Scotland.

It seems to me that this peculiar feature may be due, in some measure, to the greater relative depression of the mainland by the ice, which would lie there in a heavy mass long after the outer rim of the coast became clear of it, as we see in Greenland at the present day. Consequently there would result a much longer continuance of pressure, and a greater amount of subsidence, which might in some degree be permanent. All the Fjord coasts indeed seem to present the aspect of depressed mountain lands. Deeply cut valleys descending far below the level of the sea, with groups of islands and skerries which look like tops of sunken hills, these lineaments show that the land must have formerly stood at a much higher elevation. And it is worthy of remark that along the western border of both North and South America the Fjord districts show a sensible retreat of the land within the general trend of the coast line, as if the ocean had eaten away a bit of the country. This seems to show that the land has never quite recovered from the depression it received during the Age of ice, although it has risen again to some extent.

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[1] See Lyell's Principles, 11th ed. vol. ii. p. 196; also Proceedings of the Geol. Soc. vol. ii. p. 208; and R. Brown in the Quart. Journ. of the Geol. Soc. vol. xxvi. p. 691, 1870.

[2] GEOL. MAGAZINE, for 1872, Vol. IX.

The amount of depression in the regions of thickest ice was therefore probably far greater than is indicated by the raised shell-beds and sea-beaches. This would lead us to infer, that at the commencement of the ice-period the glaciated regions had a higher altitude and a greater area of land than they now have, which would be quite in harmony with the conditions favourable for the production of glaciers.

### LAKES AND FJORDS.

If a land of glaciers was depressed and part of the depression became permanent, it seems probable that there would be a tendency to form lakes and fjords along the border of the depressed region, more especially where its perimeter was intersected by the chief river valleys. For, owing to the subsidence of the internal area, it is evident the old lines of drainage issuing from it would be deranged and interrupted by numerous depressions, which would create a series of elongated hollows, and these hollows would become lakes or fjords after the ice vanished. If there was also, as I have already hinted, a tendency to bulge up in the region which lay immediately outside the boundary of the depressed area, this would add to the effect.

To illustrate what I mean, take Switzerland for example, or rather the region of the Alps. Here we have an irregular oval space of country which was heavily loaded with ice. From the facts connected with the Loess we have already found reason to believe that this space suffered depression during the Glacial period. Now, we find a series of large deep lakes occurring in the valleys along the skirt of this glaciated region, just where we might expect them to be from the cause I have suggested.

Take again, the seat of the great Canadian glacier. Here also we find a series of hollows running all round it from the St. Lawrence along by the great lakes, Lake Winnipeg, Lake Athabasca, the Great Bear Lake, on to the mouth of the McKenzie River. Similar features may be observed round the circuit of the Scandinavian glacier, and other examples might be readily adduced; but these will serve to illustrate my meaning.

In making the above suggestion, however, I by no means wish to call in question the soundness of Sir Andrew Ramsay's theory, according to which lake-basins are supposed to have been frequently formed by the erosive action of glaciers, and which has been so ably expounded by that excellent geologist; for I have always thought there was a large measure of truth in that theory, and in a paper of my own which was written before Ramsay's famous article appeared, I had, in fact, maintained that the bottoms of valleys and lakes in Scotland had been powerfully eroded and deepened by the long grinding of the ice,[1] an opinion which I have never seen any reason to change. But allowing Sir Andrew Ramsay to be right in his contention, I see no reason why we should not avail ourselves of this additional mode in which glaciers may have contributed to the formation of lakes, as it may help to get over some of the difficulties that have been felt by Lyell and others in applying Ramsay's explanation to many of the larger and deeper lake-basins.

We should have thus three different ways in which glaciers have contributed to the formation of lakes, viz. by moraine-dams, by erosion, and by depression.

In those lakes which are due, or partly due, to depressions caused by the ice in the way I have mentioned, it seems likely that in general they would incline to be deepest towards their upper end, or side next the centre of depression; and this is a feature that many fjords and Alpine lakes still exhibit, notwithstanding that a long period of silting up has been going on, which has had the effect of filling their upper extremity. Some of the larger lake-basins may be partly due to local depressions caused by the long-continued pressure of the ice in these basins, if special areas of weakness had existed in the strata beneath them.

I shall conclude with the following quotation from Dr. Croll, in reference to the question I have been considering:—

"It is a circumstance of some significance that in every part of the globe where glaciation has been found, along with it evidence of submergence of the land has also been found. The invariable occurrence of submergence along with glaciation points to some physical connexion between the two. It would seem to imply, either that the two were the direct effects of a common cause, or that the one was the cause of the other; that is, the submergence the cause of the glaciation, or the glaciation the cause of the submergence." . . . "The simple occurrence of a rise and fall of the land in relation to the sea-level in one or in two countries during the Glacial epoch would not necessarily imply any physical connexion. The coincidence of these movements with the glaciation of the land might have been purely accidental; but when we find that a succession of such movements occurred, not merely in one or two countries, but in every glaciated country where proper observations have been made, we are forced to the conclusion that the connexion between the two is not accidental, but the result of some fixed cause."

## ADDENDUM.

Since the foregoing pages were written I have seen another very ingenious attempt to explain the evident connection that exists between glaciation and submergence, by Dr. Penck, of Munich.[1] It is founded upon some recent results arrived at by Fischer and other German mathematicians in regard to the attractive force exerted by continents upon the sea. According to the law of gravitation, every substance in the world attracts every other substance with a force proportional to their masses. A continent of land will therefore exert an attractive influence upon the sea, and cause it to rise upon its shores to a height which will vary according to the mass of land which causes the attraction. On this account it is alleged that the surface of the ocean is not actually that of a regular spheroid, as it is generally supposed to be, but rises much higher upon the borders of continents than it does in mid-ocean. Consequently even in the same parallels of latitude the surface of the sea is not everywhere equidistant from the centre of the earth, but may show differences of level amounting to many hundred feet by reason of this attractive force which the masses of land exert upon it.

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[1] Quart. Journ. of the Geol. Soc. vol. xviii. p. 179, Feb. 1862.

Such being the case, it follows that anything which increases the mass of land will increase its attractive force and cause the sea to rise to higher levels along its border; and thus a great thickness of glacier-ice laid upon a continent by adding to its mass will draw the water towards it, and thereby raise the sea-level in its immediate vicinity; and according as the ice increases or disappears, so will the level of the sea rise or fall in proportion. Moreover the altitude of the sea-beach may vary considerably, it is said, along the border of one and the same continent by reason of the varying thickness of the ice in different parts. In this way it is conceived an explanation is found for the fact that in Norway the old terraces and sea-beaches do not coincide in elevation, but vary much in altitude even in places not very far distant from one another. It is therefore maintained that the sea may rise and fall along a coast and yet the old shore lines may be neither parallel nor horizontal.

The attractive force may be so localized that its intensity varies, and thus the influence of local masses of ice may account, it is thought, for considerable variation of sea-level in places even not far distant from one another.

These views are certainly somewhat different from those which have hitherto prevailed in regard to the regularity of the sea-level, and it seems to me are founded on an exaggerated estimate of the attractive force. If there is such a great difference in level in the surface of the sea in different places, the barometer should give indications of it. It is therefore much to be desired that every means should be taken to ascertain the relative height of the sea in various places calculated to test the accuracy of the views I have mentioned.

There are, however, some well-known facts connected with the submergence of the land in glacial times which seem to me inexplicable by the attractive force of the ice, even suppose we should grant it to have been all that is stated. For example, near Dublin shell-beds are found in Wicklow at an elevation of 1200 feet. Now when these were deposited it is difficult to see where the mass of ice or land could have existed in Ireland to have exerted the requisite attractive force. Again, we have shell-beds in Wales at 1350 feet, but no trace of submergence in the valley of the Thames, only 200 miles off. It cannot be supposed that near London the sea stood 1200 feet lower than it did at Dublin, or 1350 feet lower than it did in Wales. In the foregoing paper I have also given instances in America and elsewhere which imply subsidence of land in the interior of continents where no submergence beneath the sea occurred, and where consequently changes of the sea-level do not serve to explain the facts.

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[1] Schwankungen des Meeresspiegels, Jahrb. der Geograph. Gesellschaft zu München, bd. vii. 1882.

Col. Clarke, in his recent treatise on Geodesy (1880, p. 96), says that although mathematical calculation shows us that large tracts of country may produce great disturbances of the sea-level, it is at least questionable whether in point of fact they do. The attraction of the Himalayas as deflecting the plumb-line at various places in India has been computed, and it has been found that there is little correspondence between theory and observation, for the attraction of the Himalayas only makes itself perceptible to observation at places quite close to them.

An examination of the tables given by Mr. Buchan in the Transactions of the Royal Society of Edinburgh, showing the mean height of the barometer in various parts of the world, leads me to think that the supposed influence of the continents and high masses of land in drawing the ocean towards them, has been greatly overestimated by the authors to whom Dr. Penck appeals. For these tables certainly lend no countenance to the notion that the sea-level is subject to the great inequalities of level which he assumes.

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## VII.—SUGGESTIONS FOR A REVISED CLASSIFICATION OF THE BRITISH EOCENES.

By J. STARKIE GARDNER, F.G.S., etc.

SINCE the British Eocenes, especially of the Hampshire Basin, were mapped by the Survey, a portion of them have been separated by several writers as Oligocene. The utility of the change is not apparent in our country, where the break is seen to be purely artificial; but in other parts of Europe the Oligocenes, which embrace formations previously known as Lower Miocene, are of great importance. This change, absorbing the entire Upper Eocene fromation of the Isle of Wight, would seem alone to necessitate a reconsideration of the classification of the remainder. But the classification of the Eocene formation, invented and often modified when the beds composing it were imperfectly known, is throughout arbitrary and artificial, and scarcely yet on a scientific basis. Most of the present divisions comprise under one name the very distinct deposits formed by river, sea, or estuary, though these have been brought from quite opposite directions, and are perhaps by no means contemporaneous. Some divisions, on the other hand, are so definitely limited to sea-deposits of a particular quality, that other and contemporaneous sea-deposits have to be separated from them. The grouping adopted is in some cases quite artificial, and the existing divisions do not even approximately correspond in value, either stratigraphically, or as measures of the physical or biological changes that took place during the Eocene period.

The suppression of the term Upper Eocene, applied by Lyell and all the older authors to the classic Fluvio-Marine Series of the Isle of Wight, leaves our English group—and this I believe applies equally to the foreign Eocenes—almost without an Upper division. Under these circumstances, I submit that the following arrangement presents a more natural and useful classification than that now in use.

| | |
|---|---|
| Upper Eocene ..... ..... | Upper Bagshot.<br>Middle Bagshot. |
| Middle Eocene ..... ..... | Lower Bagshot.<br>London Clay. |
| Lower Eocene ..... ..... | Oldhaven Series.<br>Woolwich and Reading Series.<br>Thanet Series. |

If an Oligocene formation is not recognized, there will be no occasion for any rearrangement—while the change introduces no new names, and scarcely affects the very exact and admirable work of Prof. Prestwich and the Geological Survey.

All these divisions are well marked in this country, and are characterized by groups of fossils peculiar to each, and as they are perhaps better developed here as a series than anywhere on the Continent, we may well trust that the modified classification they so clearly require to reduce them to a natural system, should be adopted in countries where the sequence is possibly more difficult to trace than in our own.

The Lower Eocene group in the proposed system is singularly homogeneous, and embraces all the beds below the London Clay. There is nothing, moreover, so far as I am aware, to prevent the still older beds of France and Belgium—as far down as the Calcaire de Mons—from being grouped with it.

This group consists of sediments of marine, littoral, estuarine and freshwater origin. They are roughly classified as Thanet Beds, Woolwich and Reading Beds, and Oldhaven Beds. The Thanet Beds, developed almost exclusively in Kent, are marine, though certainly deposited close to shore. They are best seen between Reculvers and Herne Bay, and a minute study of the beds there tends to show that the upper parts of the section, divided off by the Survey as Woolwich and Reading and Oldhaven Beds, are but minor subdivisions of a single and continuous formation. This great marine deposit is traceable westward in the ancient beaches known as Oldhaven deposits, which form a zone reaching to the south and east of London as far as Croydon. It is obvious that such extensive tracts of beach or shoals could only be produced by continued retrogression of the sea, and the beaches furthest inland would be the oldest. There is absolutely no reason that I see at present why the vast accumulations of shingle at Bickley and elsewhere should not be contemporaneous with the sea deposits of Herne Bay, even though they were actually traceable as a horizontal formation directly overlying the Herne Bay formation. Beaches are the last sediments that can be left by a receding sea in an area of elevation; and to consider the Lower Eocene beaches as a distinct formation, except lithologically, can only delay any appreciation of the real conditions under which our Eocene strata were formed. The Oldhaven division, I submit, should only be recognized as one of quality—not time—partially overlying and overlapping the marine beds of the Thanet sands.

The difference between sea-deposits formed *under water* and those cast up by tidal action on the sea-margin is usually apparent enough, but the classification of the Lower Eocenes is greatly complicated by the intercalation of deposits, both brackish and purely freshwater, formed in a river estuary. These are the Woolwich and Reading Beds. In the western part of the Hampshire Basin they are chiefly mottled plastic clays, becoming eastward gradually more and more mixed with beds of sand. The mottling process has destroyed every trace of organisms, though their freshwater origin and the derivation of the material is quite apparent. The mottled clay is seen in diminished thickness at Reading, where it is underlain by freshwater clays, which, not having undergone this chemical change, still preserve their plant remains, and the freshwater deposits extend to Woolwich. Above them are brackish or salt-water estuarine deposits. While the great mass of the Oldhaven Beds show a retreating sea, these estuarine beds show encroaching salt-water ushering in the London Clay Sea, without any intervening beach, so that it becomes important to separate the period of retreat from the period of advance, as well as to recognize the position of the permanent Lower Eocene estuary, over which no beaches were ever deposited. Such estuarine beds occur principally over the west of Kent, East Surrey, South Essex, with an important outlier at Newhaven in Sussex.

The Lower Eocene of England is thus a well-marked division, consisting of fluviatile beds in the west, passing east into estuarine, and finally into marine beds. These conditions may have been and doubtless were contemporaneous to a great extent, but the divisions into which they are classified must rather be held to mean distribution of quality or origin than an absolute sequence in time. It is essential, if the extent of the old Eocene estuary is ever to be mapped and understood, that a separate term should be used for the estuarine beds, and it has been suggested that the existing term "Woolwich Beds" might with advantage be kept for them, whilst "Reading Beds" should distinguish those of purely fluviatile or freshwater origin.

Palæontologically scarcely anything is known of the Vertebrata of this Lower Eocene period, and our knowledge of the Fauna is in fact almost limited to its Testacea. Only eight specifically determined marine Gasteropods are given in the Survey list for the whole group. Of these, six range throughout, and four survived in the London Clay. Of thirty-two Conchifera, excepting the genus *Nucula*, only three are confined to the Thanet Sands as defined by the Survey, and none are stated to be special to that section of it which has been classed at Herne Bay as Woolwich and Reading Beds. Five of these species become extinct, and seven new ones appear, in the Oldhaven Beds of the Survey. These seven, and eight of the older species, survived in the London Clay. All the thirty-two species, except the seven intruders towards its close, range throughout the whole Lower Eocene group. The separation of these purely marine beds into three distinct formations breaks down palæontologically. The fauna, as a whole, is strictly littoral, and destitute of the Volutes, Cowries, and other tropical shells of the London Clay. Though species are few, individuals are drifted together in immense quantities. The flora is known from several localities, and, like the fauna, consists of few species, all of which are of temperate aspect. They are precisely similar to the so-called Miocene flora of Greenland, containing several of the so-called poplars, etc., but the only plant about which any certainty exists is a plane-tree, rather smaller in fruit and foliage than our introduced species of the present day.

*The Middle Eocene.*—This I have suggested should include the London Clay and the Lower Bagshot Series. The London Clay in fact marks such an enormous change both in the area of land and in climate, that it becomes an anachronism to place it with the preceding group. It is the most homogeneous of Eocene formations, and has the widest extent, yet the use of the term "Clay" has I believe induced several errors. At Alum Bay and Whitecliff Bay marine sands which belong to it have been placed with the completely dissimilar freshwater sands of the Lower Bagshot, and in the London Basin I believe the Ramsdell Clay to be possibly an overlying mass of true London Clay separated, exactly as a mass is seen to be at Alum Bay, by beds of sand. The formation is chiefly developed in the east, though it extends to the western extremities of the Hampshire Basin. At Harwich and at Herne Bay, only the lower beds remain, and these, though otherwise almost unfossiliferous, are crowded with rolled and macerated twigs. At Herne Bay and Whitstable, and I believe also on the north side of the Thames near Southend, fruits first make their appearance, though not approaching the vast numbers collected at Sheppey, while passing west the quantity of vegetable matter sensibly lessens. The temperature appears gradually to have increased during its formation, for *Nautilus*, Volutes, etc., commence to become abundant towards its centre, while its uppermost beds show a marked approach in character to those of the later Eocene. The fruits abound in its centre at Sheppey, and are there of a very tropical character, while in lower parts of the series, as at Swale Cliff, they seem less tropical, an Alder cone never met with at Sheppey being the commonest form. The rich Vertebrate fauna contains three Mammals, a toothed Bird (*Odontopteryx toliapicus*), and an Ostrich; sixteen Chelonians, two Crocodiles and a Serpent, and ninety species of Fish. Three hundred and fifteen Mollusca, eighty-six Protozoa, twenty-eight Crustacea, etc., complete its known fauna. The flora is probably less rich than has been supposed, not more than twenty-five species being at all common. Including almost unique specimens, the number of distinct forms does not at present, I am of opinion, surpass a hundred.

The Lower Bagshot Beds are exceedingly well developed along the borders of Dorset and Hants, and include the pipe-clays of commerce found there. They are very distinct at Alum Bay, but are difficult to identify even at Whitecliff Bay, and over the London Basin they are unfortunately correlated with the marine sands, etc., clearly produced by the retiring London Clay Sea. They possess no fauna worth mentioning, but the flora met with in the purely fluviatile deposits of the west is quite peculiar to them. Only a few pieces of Palms and a very few Dicotyledons have been preserved from the once rich deposits near Corfe Castle. Studland still yields macerated Palms and Ferns, and a few Dicotyledons, but the distinctive flora has chiefly been obtained from Alum Bay, a locality now almost barren. Large Figs, an *Aralia*, and apparently Proteaceous leaves characterize it, and give it an Australian aspect, completely different to that of any other Eocene flora, only so far met with elsewhere in the Grès du Soissonnais. It is so unlike the Middle Bagshot flora of Bournemouth, that it cannot consistently be placed in the same division of the Eocene, whilst its union with the London Clay would raise that group to the value of the other Eocene groups, which would then each comprise a marine, an estuarine, and a freshwater series, to some extent probably parallel and contemporaneous with each other.

*The Upper Eocenes.*—These would, under the suggested classification, comprise the Middle Bagshot series, consisting of the freshwater Bournemouth formation, the estuarine, and littoral Boscombe Series, and the marine Bracklesham Series. The Bournemouth Series occupies the western margin of the Hampshire Basin in Hampshire, reposing on the Lower Bagshots, with an outlier at Bovey Tracey. The flora is very rich and varied; apparently somewhat American in character, and very different to the flora preceding it. Its species amount to many hundred. The Boscombe Beds are littoral, and pass gradually into the purely marine Bracklesham. The Bracklesham Beds are not recognized west of Highcliff, and extend eastward to the vicinity of Woking and Chertsey. They are, with the exception of the lowest beds of the Barton Series, the only strata in England containing Nummulites, and it is specially remarkable that the sea which deposited them swarmed with tropical Mollusca, such as large Cowries, Cones, Volutes, *Cerithia*, *Bulla*, *Cardita*, etc., though the contemporary land fauna and flora was certainly not more tropical than that of the London Clay and Lower Bagshot.

If the Oligocene formation were required to be separated from the Eocene in England by a natural break, the division would best be placed here, for the marine fauna undergoes a great change in passing to the Barton Beds. A proportion of the commoner and smaller species of mollusca remain, it is true; but all the magnificent tropical forms disappear, and are replaced by others recalling those of the London Clay, but with the addition of a few fine forms, such as *Fusus longævus*, *Rostellaria ampla*, and *Voluta luctatrix*. The Barton Series merges into the Upper Bagshots, and these into the Headon Series. The Crocodiles, Gavials, Turtles and Feather Palms of

Hordwell show that tropical conditions had not diminished on land, though the marine fauna had become so conspicuously more temperate. The Headon Beds are first fluviatile, then marine or estuarine, but singularly the fauna of Brockenhurst recalls that of Bracklesham almost as much as the more immediately preceding Barton fauna. Fresh fluviatile beds come in and the strata continue to be of freshwater origin, until the Bembridge Marls in the east of the Isle of Wight betray brackish water, and the still newer Hempstead Beds in the west even more decided marine conditions. The temperature during the later stages seems gradually to have diminished, for fresh species of the same genera of mollusca continually succeed each other, while the flora, without changing its general character, seems to have lost its more tropical forms. It is unnecessary to describe the beds, but they are more distinctly freshwater to the west than east. They are crowded throughout with fossils, the assemblage of Pulmonate Gasteropods in the Bembridge Limestone being especially remarkable. In places I have seen this bed crowded with casts of the eggs and young of the gigantic *Bulimus*, now confined to the West Indies, and large species of *Achatina* and *Helix* are well-known fossils from it. Between Yarmouth and Gurnet Bay the shore used to be fairly sprinkled with scutes of turtle and crocodile and mammalian teeth, and the floras of Hempstead and Gurnet Bay are celebrated.

I do not think, if three divisions of the Eocene and an Oligocene formation are to be maintained, that any other arrangement would separate the divisions where natural breaks occur, and yet leave them of approximately the same importance.

It is obvious, from the extension of similar formations over Northern Europe, and their absence to the South, as well as from their English distribution, that the Lower Eocenes and the London Clay were deposited by a sea whose chief extension lay in northern directions. The Lower Eocene deposition was accompanied by a slight depression in the littoral and delta areas, and was checked by a slight upheaval. During the consequent retreat of the sea, the great Oldhaven beaches must have been formed and left stranded. The fauna and flora show the climate to have been almost as temperate as at the present day, and hence it must be inferred that the Greenland Lower Eocene rocks, which are barren of plants, were formed during this period. The London Clay deposition was favoured by greater depression, during which the sea penetrated to the utmost limits of Hampshire and into Dorsetshire. In the east the sea must have been over a hundred fathoms deep, but westward it was shallower, and the "clay" is finally represented by shingles and sand. During this period a remarkable change took place in the climate, which became almost tropical, causing the older flora of the temperate Eocene period in England to migrate towards the Pole and establish itself in Greenland. The so-called Miocene flora, of Greenland at least, is a continuation of our Lower Eocene flora, and probably belongs to the Middle Bagshot or most tropical of English Eocenes.

It is interesting to trace out the presence of a large river flowing from west to east throughout the whole of this period. We find that its delta advanced and receded with the depressions and elevations which led to the formation of this part of the Eocene.

The Bracklesham Beds are the deposits of an almost tropical sea, which extended south over France, but is not traceable north of the Thames. The depression seems to have travelled from south to north-east and caused the outfall of the Eocene river to shift towards Hampshire. The Barton Beds show an influx of the northern sea into the Bracklesham Sea, resulting in the migration of all the most tropical forms — so that the dividing isthmus which previously existed must have been broken through. The position of the river was scarcely changed and the land fauna and flora remained tropical until the close of the Headon period. Upheaval having caused the recession of the Barton Sea. the southern sea again appeared in the Brockenhurst Beds of the Middle Headon. The changes of level during the Oligocene in England are similar, but affected smaller areas, and were accomplished in a gradually diminishing temperature.

I have touched very briefly on the physical conditions which prevailed during the Eocene period, as my views on this part of the subject have been already published. These conditions can, however, be traced with great minuteness and comparative certainty.

## NOTICES OF MEMOIRS.

I.—1. Silurische Korallen aus Nord Russland und Sibirien; verzeichnet von G. Lindström. Bihang till K. Svenska Vet. Akad. Handlingar, Band 6, No. 18.—Silurian Corals from North Russia and Siberia, described by G. Lindström. Supplement to the Transactions of the Royal Swedish Academy of Science, Stockholm, 1882. 8vo. pp. 23, with a Plate.

2. Anteckningar om Silurlagren på Carlsöarne. Af G. Lindström. Öfver. Af. Kongl. Vet. Akad. Forhandlingar, 1882, No. 3.—Notes on the Silurian Strata of the Carls Islands. By G. Lindström. Proceedings of the Royal Swedish Academy of Science. 8vo. pp. 30, with a Plate and Five Woodcuts.

IN the first of these papers Prof. Lindström describes 27 species and varieties of corals, which have been collected from Silurian strata in four different and widely separated localities in Northern Russia and Siberia. Most of the forms belong to the familiar Silurian genera *Favosites*, *Heliolites*, *Halysites*, etc.; but in addition to these, there are no fewer than three new genera, which have been named *Rhaphidophyllum*, *Cyrtophyllum*, and *Palæarea*; this last is remarkable from the similarity of its structure, in many important respects, to that of the Tertiary genus *Litharea*. From a table appended it appears that 17 of these Siberian species occur also in Sweden; 12 in the English Silurian, and 8 in North America (including *Halysites catenularius*, L., and *H. escharoides*, Lam., which are omitted from the list of American species, though of common occurrence in that country). It is curious to note that two distinctive American species, *Calapœcia cribriformis*, Nich., and *Columnaria alveolata*, Goldf., make their appearance in the Siberian beds, though they have not as yet been recognized in the intermediate Silurian areas of Western Europe.

The second paper contains a detailed description of the Silurian strata displayed in the Great and Small Carls, two small islands situated within a short distance of the west coast of the Isle of Gotland. The beds consist of an underlying series of soft greyish shales, which in places have been remarkably contorted, and their upper surfaces denuded, previous to the deposition of the limestone strata which cover them. The limestones are distinguished by being in many instances almost entirely composed of Corals and Stromatoporæ, and some of the beds are made up of tightly packed individuals of but a single species, whilst in others two or three species have lived and died together, so as to form beds which reach a thickness of 16 feet. Professor Lindström gives a list of the fossils from these islands, and compares them with those met with in similar strata on the Isle of Gotland. The characters of a new genus of corals, *Helminthidium*, are also defined. In an appendix he refers to the descriptions of the corals from these islands given by Dr. W. Dybowski in his "Monographie der Zoantharia Sclerodermata rugosa aus der Silurformation Estlands, Nord-Livlands und der Insel Gotland," and shows pretty conclusively that the 12 species therein described, 8 as new, may be reduced to 6, and these were all previously known and described. G. J. H.

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## II.—British Association for the Advancement of Science, Fifty-Second Meeting, Southampton, 23rd August, 1882.

[C. W. Siemens, Esq., D.C.L., LL.D., F.R.S., etc., *President.*]

### A.—Titles of Papers Read in Section C. (Geology).

*President:* Robert Etheridge, Esq., F.R.S., F.G.S., etc.

The President's Address.

*Professor J. Prestwich, M.A., F.R.S.*—Notes relating to the Drift Phenomena of Hampshire:—1. Boulders. Hayling Island; 2. Chert débris in the Gravel; 3. Elephant Bed, Freshwater Gate.

*H. B. Woodward.*—Notes on the Bure Valley Beds and the Westleton Beds.

*Professor V. Ball, M.A., F.R.S.*—On the Sources of the Salt Supply of India.

*Professor W. C. Williamson, F.R.S., and W. Cash.* — Preliminary Report on the Flora of the "Halifax Hard Bed," Lower Coal Measures.

*C. E. De Rance.*—On the Iron and Lead Measures of Tynehead, Alston Moor.

*W. Keeping, M.A.*—On the Geology of Cardigan Town.

*W. Pengelly, F.R.S.*—On the Post-Miocene Deposits of the Bovey Basin, South Devon.

*E. Wethered.*—On the Origin of the Hæmatite Deposits in the Carboniferous Limestone of South Wales.

*Professor J. Milne.* — Report on the Earthquake Phenomena of Japan.

*Professor W. J. Sollas, M.A.*—Report on the conditions under which ordinary Sedimentary Materials may be converted into Metamorphic Rocks.

*Rev. G. F. Whidborne, M.A., and Professor W. J. Sollas, M.A.* — On some Fossils from the Inferior Oolite.

*C. E. De Rance.*—Report on the Circulation of the Underground Waters in the Permeable Formations of England.

*A. R. Hunt, M.A.*—Evidence of Wave-Action, at a depth of 40 fathoms, in the English Channel.

*W. Whitaker, B.A.*—List of Works on the Geology and Palæontology of Oxfordshire, Berkshire, and Buckinghamshire.

*Professor James Thomson, LL.D., F.R.S.*—Mention of an example of an early stage of Metamorphic Change in an Old Red Sandstone Conglomerate near Aberfoil.

*Professor James Thomson, LL.D., F.R.S.* — On features in Glacial Markings noticed on Sandstone Conglomerate at Skelmorlie and Aberfoil.

*Professor J. Prestwich, M.A., F.R.S.*—On the Equivalents in England of the Sables de Bracheux, and on the Southern limits of the Thanet Sands.

*J. S. Gardner.*—Suggestions for a Revised Classification of the British Eocenes (see p. 466).

*J. W. Elwes.*—On the Classification of the Oligocene Strata in the Hampshire Basin.

*E. B. Tawney, M.A.*—On the Outcrop of the Brockenhurst Beds near Lyndhurst.

*Dr. C. Ricketts.*—On Subsidence as the Effect of Accumulation.

*J. S. Gardner.*—The Cause of Elevation and Subsidence of Land.

*Professor W. Boyd Dawkins, M.A., F.R.S.*—On the Geology of the Channel Tunnel.

*C. E. De Rance.*—On Proposed Channel Tunnels in their Geological Aspects.

*W. Topley.*—On the Synclinal Structure of the Straits of Dover.

*R. J. Ussher.*—Report on the Exploration of Caves in the South of Ireland.

*T. W. Shore and E. Westlake.*—On the Southampton Artesian Well.

*Rev. H. W. Crosskey.*—Report of the Committee on Erratic Blocks.

*G. R. Vine.*—Report on the British Fossil Polyzoa (Jurassic Species).

*Professor W. J. Sollas, M.A.*—On the Formation of Flints.

*Rev. E. Hill, M.A.*—Problems in the Geology of the Channel Islands.

*Rev. A. Irving, B.Sc.*—Notes on Alpine Post-Carboniferous (Dyassic) and Triassic Rocks.

*Professor J. D. Everett, F.R.S.*—Summary of Reports of the Committee on Underground Temperature.

*R. B. White.*—Notes on the Geology and Mining of the United States of Columbia, S.A.

*W. Topley.*—Report on the Progress of the Geological Map of Europe.

### B.—TITLES OF PAPERS, BEARING UPON GEOLOGY, READ IN OTHER SECTIONS.

### SECTION A.—PHYSICAL SCIENCE.

*Professor Everett.*—(1) Report of Committee on Underground Temperature. (2) Synopsis of all previous Reports of this Committee.

*Professor Schuster.*—Report of Committee on Meteoric Dust.

*Professor Balfour Stewart.*—On a Supposed Connexion between the Heights of Rivers and the Number of Spots on the Sun.

*G. H. Darwin.*—On an Estimate of the Earth's Rigidity.

### SECTION B.—CHEMICAL SCIENCE.

*Professor Divers and Marachika Shimosé.*—On the Occurrence of Tellurium and Selenium in Japan.

*Professor von Baumhauer.*—On the Application of the Diamond to Mineralogical and Chemical Analysis.

### SECTION D.—BIOLOGY.

*W. S. Duncan.*—Evidence as to the Scene of Man's Evolution, and the prospects of proving the same by Palæontological Discovery.

*W. Pengelly, F.R.S.*—Prehistoric Remains in the Deposits of the Bovey Basin, South Devon.

*Professor Boyd Dawkins, F.R.S.*—The Light thrown by the Exploration of Caves on the Conquest of Britain.

### SECTION E.—GEOGRAPHY.

*J. Thomson.*—On the Geographical Evolution of the Tanganyika Basin.

*Professor V. Ball.*—On the Identification of certain Ancient Diamond Mines in India.

*M. Pierre de Tchihatchef.*—The Deserts of Africa and Asia.

### SECTION G.—MECHANICAL SCIENCE.

*J. Clarke Hawkshaw.*—The Channel Tunnel.

## REVIEWS.

### I.—TABULAR VIEW OF THE GEOLOGICAL SYSTEMS, WITH THEIR LITHOLOGICAL COMPOSITION AND PALÆONTOLOGICAL REMAINS. Especially adapted for Students preparing for the Royal Military Colleges of Woolwich and Sandhurst. By Dr. E. CLEMENT. (London: A. Swan Sonnenschein & Co., 1882.)

WE are sorry that we cannot endorse the opinion expressed by the author of this work in his preface that it "will be found of great use to both masters and pupils": its errors, both of omission and commission, are so numerous that any utility which such a work might otherwise possess appears to us to be entirely destroyed. In the some dozen pages on Stratigraphy, for instance, we find no mention of the Pre-Cambrian rocks of England and Wales, nor of the Rhætic beds and Inferior Oolite; erroneous positions are assigned to the Thanet sands and to the Hempstead beds, which are placed above the Woolwich and Bovey Tracey series respectively; and the classification of the Cambrian and Silurian strata is certainly not the best that could be adopted. The lists of economic products and fossil remains are equally unsatisfactory; we note in the former that Common Salt is given as a product obtained from the Lias, while the well-known Ironstones of that formation are not mentioned; in the latter that *Chara* and *Astropecten* are placed with the Conchifers and *Hippurites* with the Plantæ; moreover, many of the fossils given are not characteristic of the groups in which they are placed, e.g. *Atrypa reticularis* is given as Devonian, and *Plagiostoma gigantea* as Lower Oolite. We very much question the truth of the statements (pp. 13 and 14) that mammals allied to Monkeys appear in the Chalk, and that the Cretaceous "coprolithes" are all "fossilized excrements of fishes." In the table of rocks and minerals (pp. 17-19) such important species as Tourmaline, Garnet, and Diallage are unnoticed, while a place is given to the comparatively unimportant Azurite, Meerschaum, and Strontianite. Porphyry, which is defined on p. 22 as any rock in which "distinct crystals of one or more minerals are imbedded," has here assigned to it a definite composition of $Al_2(SiO_3)_3$: the formulæ given for Mica and Olivine would hardly be accepted by most Mineralogists, and the definition of Trachyte as "Glassy Felspar with crystals of ditto" will not commend itself to many Petrographers. It is, however, in the glossary of "most essential" terms (pp. 20–23) that the slipshod character of this compilation is most apparent; no distinction, for example, is made between rock cleavage and the cleavage of crystals, nor between cliffs and escarpments; such terms as False-bedding, Overlap, Denudation, and Foliation are conspicuous by their absence from a list which includes Berg-mehl and Plumbago, and many of the so-called definitions do not deserve the name. The following examples require no comment:—"Alluvium: A formation composed of fragmentary matter collected together by the ordinary action of water." "Dislocation: Stratified rocks, when displaced from the horizontal position in which they were deposited, are called dislocated."

Many more such examples might be given, but we think enough has been said to show that the work can scarcely be recommended as a safe guide to either students or teachers. E. W. S.

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II.—JOURNAL OF THE ROYAL MICROSCOPICAL SOCIETY. Series II. vol. i. parts 4–6, and vol. ii. parts 1–4. (Nos. 23–29; August, 1881—August, 1882.)

THIS useful Journal continues to be conducted on a very liberal scale, both scientifically and technically. It contains the Transactions and Proceedings of the Society, and a summary of current researches relating to Zoology and Botany (principally Invertebrata and Cryptogamia, with the Embryology and Histology of the higher Animals and Plants), and Microscopy. The whole is highly creditable to the enthusiastic editor, Mr. Frank Crisp, one of the Secretaries of the Society, and his talented and willing assistant-editors, Messrs. Bennett, Bell, Ridley, and Mayall, also Fellows of the Society. In the Parts before us are ten original papers on various matters in Microscopy. Professor Duncan's elaborate Presidential Address, reviewing the aspects and value of the results of high magnifying powers, is a most valuable addition to this branch of the Society's study and research. There are also nine original papers on natural history, treating of Mites. Spider-web, a new boring Annelid, Spicules of Echinoidea, peculiar Sponge-spicules, Diatomaceæ, and Bacteria, Bacillus, etc., touching on the medical question of their probable malignant influence in some diseases.

For the benefit of microscopists each part of the Journal (published in February, April, June, August, October, and December) contains the following useful, and indeed necessary, Tables :—I. Numerical Aperture; II. Conversion of British and Metric Measures; III. Corresponding Degrees in the Fahrenheit and Centigrade Scales; IV. Refractive Indices, Dispersive Powers, and Polarizing Angles; V. Magnifying Powers.

The Summary of current researches consists of abstracts of, or extracts from the more important articles relating to the chosen subjects (with references to originals), as contained in British and Foreign Journals and Transactions, chiefly those added to the Society's Library. The following notes bear evidence that these, as well as the other contents of this valuable periodical, are of interest to geologists.

Those to whom the study of Cephalopoda is of special interest will find a reference to the particulars about existing giant Squids, such as the *Architeuthis*, at p. 586, vol. i. Some found dead on the Grand Banks, by the Massachusetts fishermen, had bodies 15 feet long, and 18 inches in diameter; some had arms 36 feet long; and one was estimated to weigh 1000lbs.

P. Girod's researches on the ink-bag and ink of Cephalopods (p. 876, vol. i.) are also of considerable interest, especially in view of the frequent occurrence of such ink-bags in the fossil state. He finds that the ink contains—

| | |
|---|---|
| Carbon | 53·6 to 53·9 |
| Hydrogen | 4 and a fraction |
| Nitrogen | 8·6 to 8·8 |

Its constituents are—in 100 parts—

| | |
|---|---|
| Water | 60 |
| Mineral substances | 8·613 |
| Insoluble organic substances | 30·536 |
| Extractive matters | 0·851 |

The mineral substances include calcium, magnesium, sodium, potassium, and iron; and the acids include carbonic, sulphuric, and hydrochloric, but not phosphoric acid.

C. D. Walcott's investigations on the structure of Trilobites and their appendages are brought forward at p. 736, vol. i. He finds the ventral membrane, intestinal canal, subcapitular appendages, those of the thorax and pygidium, and the respiratory apparatus. J. D. Dana criticizes these results, and suggests that these are portions of the outer ventral shell, serving as attachments for the thin membranous articulated appendages already attributed to Trilobites.

S. H. Scudder's remarks on the structure and affinities of Carboniferous Myriapoda, to the effect that they cannot be referred to the *Diplopoda* nor to the *Chilopoda*, but should be placed in a new suborder, for which the name of *Archipolypoda* is proposed, are to be found at p. 598, vol. i.

The researches by Messrs. Vine and Shrubsole in fossil Polyzoa (Jurassic and Carboniferous) are noticed at p. 882, vol. i.

Seguenza's elaborate memoir on the Tertiary Fossils of the Province of Reggio in Calabria is noticed at p. 594, vol. i.; and a careful abstract of the Polyzoa (Bryozoa) therein described is given. Some new genera and species, living in the Australian seas, and described by Mr. R. H. MacGillivray, are enumerated at p. 593.

The valuable results of A. G. Nathorst's investigations of the track-marks of marine and other Invertebrata, and of the natural trailings of aquatic plants, in elucidation of fossil tracks and trails, and of the so-called Fucoids, etc., are given in full abstract (after T. Fuchs) at p. 324, etc., vol. ii. Also his researches on the fossil conditions of *Medusæ* or Medusoid animals in the same Cambrian strata of Sweden, at vol. ii. p. 326. Notices of these very interesting illustrations of hitherto doubtful Palæozoic fossils were also given in the GEOLOGICAL MAGAZINE for January, 1882, pages 22 and 24. A noticeable feature in Mr. Nathorst's work is the careful list of all previous memoirs treating of track-marks,—a bibliography of considerable extent, but somewhat neglected hitherto. We may remark that in the Portfolios of Drawings in the Library of the Geological Society of London are some original sketches of Crustacean, Molluscan, and other tracks by the late Hugh Strickland.

At p. 394, vol. ii., we have a notice of the conclusion arrived at by Meunier-Chalmas,—namely, that the Eocene genus *Ovulites* is in his opinion identical with *Penicillus*, Link, *Nesea*, Lamx., and *Coralliodendron*, Kützg., for which he establishes a new section of *Siphoneæ*, distinguished by their dichotomous branching. One of the Eocene species is said to be closely allied to the existing Mediterranean *Coralliodendron mediterraneum*. These have been previously regarded as belonging to a group of *Protozoa*, known as the *Dactyloporidæ*, to which also belongs *Triplopoɪella*, found by Steinmann in a limestone of the Lebanon.

How far Diatomaceæ may serve geologists in recognizing fluviatile and marine deposits, the researches of Dr. F. Bossey on the mud-banks of the Thames give some good indications (p. 94, vol. ii.). Mud taken from seven different localities showed the following proportions of fresh-water and salt-water forms:—

| | Fresh-water. | Salt. |
|---|---|---|
| Half a mile above Teddington Lock | 66 | 0 |
| One mile below Teddington Lock | 54 | 0 |
| Kew | 52 | 37 |
| Blackwall | 39 | 45 |
| Estuary of the Thames | 9 | 60 |

The examination of the hard diatom-rock of Nykjöbing in Jutland gave W. Prinz some interesting results as to the structure of some Diatoms (see vol. i. p. 507). His views are criticized by A. Grunon, p. 246, vol. ii.

In the Tertiary shales of Warnsdorf, Bohemia, K. J. Tavánek has found remains of a Moss (*Fontinalis?*), with Diatoms in a very good state of preservation; one of these (*Melosira arenaria*) still exists in Bohemia.

Mr. H. G. Hawks' enumeration of the uses to which diatomaceous earth is applied (p. 785, vol. i.) is of great interest. It is used as a material in the manufacture of soluble silica and soluble glass, of porcelain, of some cements and artificial stones; as manure; as a drying material in laboratories; as a vehicle for mineral oil in lighting fires; for making floating bricks; in the manufacture of dynamite, giant powder, lithofracteur, and other explosives; and of some soaps. It is said also to be an important constituent of at least one tooth-powder ("sozodont"); and it has been used in packing ice cases.

That Sponge-spicules constitute the chief material of some chert from the Carboniferous Limestone, as proved by Prof. W. J. Sollas, is mentioned at p. 615, vol. i.

A philosophic warning for geologists occurs in the abstract of T. Fuchs's paper on Pelagic and Deep-sea Fauna, at p. 485, vol. ii., where it is pointed out that aggregations of animals analogous to those characteristic of abyssal depths may occur in the dark caverns under the coral-reefs of Brazil, thus bringing deep-sea forms in near contiguity with those of littoral habits.

The very questionable occurrence of fossil organisms in meteorites, supported by Hahn, Karsten, and Weinland, is noticed at p. 722, vol. i. The refutation by Vogt is fully given at p. 176, vol. ii.; and has been already referred to in the Geol. Mag. Sept. 1882, p. 424.

The notes on preparing thin sections of coal and mica-schist, at pp. 577 and 578, vol. ii., are worthy of attention. T. R. J.

## CORRESPONDENCE.

### ON THE CAUSES OF ELEVATION AND SUBSIDENCE.

Sir,—In June of last year I contributed an article to the Geological Magazine in which I endeavoured to show that any addition of weight on any part of the earth's surface produced a subsidence, while any removal of weight was followed by a tendency towards elevation. The evidence I brought forward covering a very wide range, and my article having been brief, I barely alluded to some sections of it, and only remarked in reference to accumulations of ice that in the Glacial period they seemed to have been accompanied by subsidence, and that Greenland appeared to be sinking at the present day under its ice-cap. On the 21st June of this year, Mr. T. F. Jamieson, F.G.S.,[1] read a paper before the Geological Society, the published abstract of which represents his view of the subject to be "that the depression of the land was caused by the weight of ice laid upon it, and the re-elevation by the disappearance of the ice." I do not know whether Mr. Jamieson claimed complete originality for his hypothesis, but in any case the evidence collected by him must be of great value and is very welcome.

J. Starkie Gardner.

### GREAT POST-GLACIAL FLOODS AND THE PLUVIAL PERIOD.

Sir,—In reference to Mr. H. H. Howorth's statement (see Geol. Mag. Sept. p. 417) that Mr. Belt urged that these Floods (Gravel-Period) were caused by the pounding back of the European rivers, and the consequent formation of a European lake by a Great Atlantic Glacier (see Thomas Belt's papers, Quarterly Journ. of Science, No. 44, Oct. 1874, and July, 1878, pp. 316–360), I may observe that (in the Quart. Journ. Geol. Soc. 1868, vol. xxv. p. 10) I had previously stated that, "the gorging of ice at the mouth of the Thames, Seine, and Somme, may have assisted in the production of some of the remarkable gravel-beds in these rivers."

With regard to Mr. Howorth's criticisms on the uniform motion of rivers (*op. cit.* p. 419), I may observe that if the water in a navigable river did not tend not only to a uniform mean motion, but to uniform maximum and minimum motion in the respective parts of its channel, floods or short water would ensue.

I particularly excepted the case of floods, because they occur whenever the motion of the stream at any part deviates by excess from its uniform mean motion. If Mr. Howorth will refer to my paper in the Phil. Mag. 1853, pp. 258–274, he will find that I have particularly noticed the inequality of the current in rivers, and show that the origin of horse-shoe bends is attributable to inequalities of rainfall, and of speed of the water in different parts of its channel.

From Mr. Howorth's criticisms of the various opinions, explanations and theories of Sir Charles Lyell, Messrs. Prestwich, S. V. Wood. T. Belt, Croll, myself, and others, I conclude that the explanations of these geologists all fail to satisfy him; nevertheless he is ready with a theory of his own, calculated to meet all the difficulties of the student of Quaternary Geology. This, so far as I am able to comprehend it, is a modification of, but far transcends the wildest speculation of M. Adhémar.

Alfred Tylor.

Shepley House, Carshalton, Surrey,
*Sept.* 16*th*, 1882.

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[1] See the full text of Mr. Jamieson's paper, Geol. Mag. Sept. and Oct. 1882, pp. 400 and 457.—Edit. Geol. Mag.

THE
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**No. XI.—NOVEMBER, 1882.**

## ORIGINAL ARTICLES.

### I. Earth-Movements,—Tremors and Pulsations.

THE subjoined communication, which appeared in the columns of the *Times*, for October 11th, from Professor John Milne, F.G.S., of the Imperial College, Tokio, Japan, is of so much importance to Physicists and Geologists all over the world, that we should be negligent in our duty to our readers did we not specially call their attention to it. It is easily to be conceived that, in a country like Japan, where Earth-Movements and Earthquakes are of constant occurrence and alarming in magnitude, the Government and the people alike see the vital importance of studying their attendant phenomena, and whether in building houses, chimneys, laying pipes and drains, they are glad carefully to consider how practically to guard these against destruction by this common form of dislocatory disturbance. A Society known as the "Seismological Society of Japan" has been established by Prof. J. Milne some two or three years since in Tokio, and publishes a most excellent journal; and all scientific men, are invited to co-operate in making seismological observations. Hitherto, disturbed areas, where earthquake-movements are developed in intensity, have alone been carefully studied and their phenomena recorded; but Prof. Milne's aim is to demonstrate, that, by the use of delicate instruments, the most stable areas in the world can all be shown to be subject to more or less sensible tremors and pulsations of the solid crust, and that it is the duty of all scientific men, who can command the use of suitable appliances, and delicate test-apparatus, to examine into, collect and record these more minute, but none the less important and measurable strains and earth-throbs.

If we could penetrate some silent umbrageous recess in a tropical forest, and could there have conveyed to us by a microphone all the to us inaudible sounds going on around, our brain would be stunned by the vast pulsations of animal and vegetable life throbbing everywhere—the rushing sap in the trees, the bursting buds, the growing plants, the busy insects—in fact all sounds of life would be transmitted to our sharpened hearing in a torrent of audible vibrations.

If, instead of contemplating the pulse-throbs of organic beings, we could cause our microphone to bear upon the ground beneath us, we should speedily be aware that the inorganic materials of which our globe is composed are also in a state of unrest, suffering slowly everywhere from pressures, strains, dislocations, and displacements, giving rise to earth-currents, tremors, and other indications of disturbance of equilibrium, proving that slow but ceaseless changes are for ever taking place beneath our feet. However minute then these earth-pulsations are, they deserve to be recorded by the cosmologist, with the same care that the biologist bestows upon the movements of living organisms, and we trust that Prof. Milne's efforts to awaken an interest among the physicists and geologists of this country in these researches may be crowned with success.—EDIT. GEOL. MAG.

## EARTH-MOVEMENTS.

By Professor JOHN MILNE, F.G.S.,
Imperial College of Engineering, Tokio, Japan.

RECENT investigations appear to have shown that *terra firma* is a phrase indicating a condition of our solid earth which scientifically has no existence. The crust of the earth is in a state of constant movement. When these movements are sudden and violent, we call them earthquakes; transient shiverings, which require the aid of instruments to make them visible, we call earth tremors; movements of longer period and greater amplitude, causing large areas, like islands and continents, to rise and fall like rafts upon the ocean, are called oscillations. To express the study of the whole of these Earth-movements it would here be convenient to have a special term. Seismology, or the study of earthquakes, is principally indebted for its present scientific aspect to the labours of Mr. Robert Mallet, who, in his classical work on the Neapolitan earthquake, and in his numerous other writings, showed the world that earthquake phenomena, when properly questioned, could give solutions to various problems respecting the physics of the globe, which previously had not been thought of. In the methods employed by him, working tools were left for all succeeding seismologists. Before his time earthquake literature was little more than the records of strange occurrences and dreadful calamities; but in his hands seismology became a science. So much having been accomplished by an Englishman for the first and most conspicuous branch of the study of Earth-movements, it certainly devolves on us vigorously to prosecute the remaining, and what are probably the more important, branches of this study.

We have learnt that earthquakes are the result of a complexity of causes. Principal causes are usually so modified by secondary ones that it is difficult and often impossible to assign definite reasons for these terrible phenomena. Earthquakes are to our continents what storms are to the ocean; in both we have phenomena which attract attention by their appalling nature. They are anomalies in nature's operations which come upon us suddenly and are foretold with difficulty. In the ocean, however, we have phenomena which are more regular and universal in their working than the storms, and which can be predicted with certainty. These are the tides. In these motions of the earth's crust it is very probable we have phenomena which are analogous to tides as well as storms, and which, like the tides, are to be classed among the law-abiding phenomena of nature's operations. These are tremors and oscillations.

Of late we have learnt much about earth tremors from Messrs. George and Horace Darwin, who, while endeavouring to measure the lunar disturbance of gravity, have shown us that even in Britain we have a soil which is subject to storms of microscopic earthquakes. These disturbances were so numerous and of such a magnitude that they eclipsed the results which were being sought for, and the problem of experimentally measuring the pull exerted by the moon had to be relinquished. In Japan microscopic movements of like character have been recorded with apparatus similar in principle to that employed by Messrs. Darwin. Among the earliest work done in the investigation of these minute movements was that inaugurated by Timoteo Bertelli, of Florence, who, in 1870, announced that he had perceived the earthquakes which shook Romagna, although to ordinary observers in Florence these movements had not been perceptible. Although doubt was cast upon Bertelli's work, it appears to have been the origin of a series of microseismical observations, a distinguished leader in which is Professor M. S. de Rossi, who told us in 1874 that almost all large earthquakes were preceded by microseismic storms. Another result which has been announced is that the microseismic motions increase with the fall of the barometer. A third result is that these disturbances are sometimes simultaneously recorded throughout the whole of the Italian Peninsula.

These and other equally interesting results have already been more or less clearly established, and the object in here mentioning them is practically to show that earth tremors may have a real and possibly a universal existence. It may not have occurred, perhaps, to many Englishmen that the mountains and plains on which they dwell are probably in a state of perpetual vibration; that England is, in fact, quivering like a mass of jelly in a spoon; that there is a continuous tremulous motion going on everywhere in the earth. In earth tremors we have one of the most universal of nature's phenomena, and one which has hitherto been almost entirely overlooked.

From accidental observation and from direct experiments we know earthquakes can produce electrical phenomena of alarming magnitude in our telegraph lines and cables. May we not, then, ask what is the connexion between earth currents so observed and microseismic storms? Are they connected with disturbances in the earth's magnetism which are being so studiously recorded in all accessible parts of the globe? Do they hold any relation to variation in earth temperature? In short, what are these movements, and what connexion have they with phenomena exerting an influence upon our every-day existence?

To science the observation of these disturbances opens a new realm for investigation. The observations made in Italy apparently indicate that they may hold some relation to the rising and sinking of our land which Mr. George Darwin, in his last report to the British Association, has shown is a consequence of barometrical variation. Their *maxima* may, perhaps, be related to the elastic tides of the earth's crust, and, therefore, they may be as periodic as the tides in the ocean. From time to time we read of the collapse of underground excavations in mines, resulting in the loss of life and property. We may reasonably ask whether these catastrophes do not hold some relation to the palpitations of our earth's crust, which hitherto have not been investigated. In instances like these, may they not have been analogous to the last straw on the camel's back and the ultimate cause of ruin and destruction?

To point out the rewards, not only scientific, but also directly utilitarian, which might accrue from the systematic investigation of earth tremors, is at present only a task involving speculations.

These movements of the ground on which we dwell being phenomena so universal, and which promise such rich rewards to those who successfully prosecute their investigation, it surely becomes our duty to establish the necessary means for their examination.

After the earth tremors we have to consider the existence of a class of movements on our soil which yet require further observation before we are assured that they can be recorded experimentally. These are similar to those spoken of by Mr. George Darwin, who has shown us that an increase in barometrical pressure over an area is equivalent to loading that area with a weight, in consequence of which it would be depressed. Sir William Thomson likens this phenomenon to placing a pile of sovereigns on a mass of jelly. When these loads are removed the depressed area rises, and an oscillation of the earth's crust has been completed. Earth tremors have been unnoticed by ordinary observers because the amplitude of their motion was so small; oscillations like these have been overlooked because the period of their vibration is so long. Whether movements analogous to these, which may be caused by atmospheric pressure, and which are of great amplitude and long duration, exist in nature, is at present to some extent problematical. That they exist and have a connexion with many phenomena which are at present unintelligible is not improbable. Among these phenomena may be mentioned the abrupt oscillation in the levels of water which, from time to time, have taken place in inland lakes. Thus we have the *Seiches* and *Ruhssen* of Switzerland in lakes like Geneva and Constance, where the waters, for reasons without definite explanation, rise suddenly through a distance ranging from a few inches to a yard. The like phenomena exist in the Baltic, in the great lakes of America, and, probably, all over our globe. Similar phenomena appear sometimes to have been connected with great earthquakes, in countries at long distances from the scene of destruction, and the water in lakes and ponds has slowly run backwards and forwards without any motion being perceptible in the ground by those who observed the strange movement of the water. This appears to have been the case in England in 1755, on the day of the great Lisbon earthquake, when the water in the lakes and pools oscillated to and fro like the water in a basin which is being slowly tilted. At Lisbon the vibrations of the ground were rapid and severe; but when they reached England it seems probable that the period of motion had been so far lengthened that the vibration of the ground was too slow to be perceived excepting in the water as already mentioned. Whether this was definitely the case or not I am unprepared to say, but certainly these phenomena have their parallel in experiments upon artificially-produced vibration of the earth; as the disturbance radiates from its centre, the waves, if they may be so-called, become longer in their period.

Surely, when we know as much as this, for us to determine whether these slow pulsatory movements, perhaps emanating from great depths, are taking place in the earth on which we live, is a legitimate investigation.

As a field from which a rich reward might be gathered by those who are willing to labour in it, and which would yield results of the highest importance to those working at earth tremors, it may be pointed out that almost every inhabitant of a civilized country who dwells within 100 yards of a railway line experiences storms of the most interesting microscopic earthquakes produced by passing trains, every vibration of which might be recorded. Artificial tremors like these, and many others produced in a similar manner, have hitherto only been regarded as the bugbear of practical astronomers and experimental physicists.

Before the United States Naval Observatory at Washington was erected Professor H. M. Paul was deputed to make a tremor survey, and to discover stable ground. Sir George Airy, who was troubled with the tremors of Greenwich Hill, has left a record of his battles with these obtruders in apparatus designed to eat them up.

Lieutenant-Colonel Palmer, when observing the transit of Venus in New Zealand in 1874, intrenched himself against the enemy by digging pits. Captain Kater, with his pendulums, rather than fight the foe, fled out of London.

All that science has usually done for artificially-produced tremors has been to destroy them, and, if not successful, to bury them with imprecations.

How far a set of diagrams which tremors like these could be made to draw would be supplemental to the work which will be accomplished sooner or later by those who undertake the observation of natural tremors it is needless to dilate upon. With telescopes and other instruments we are measuring the motions of the heavenly bodies; with thermometers, barometers, and other instruments we are perpetually examining the temperature and pressure of the atmosphere; with tide gauges we note the rise and fall of the ocean. Surely after this it becomes imperative that we should pay some attention to the movements of the land on which we dwell.

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## II.—On some Remains of Plants, Foraminifera and Annelida, in the Silurian Rocks of Central Wales.

By Walter Keeping, M.A., F.G.S., Keeper of the York Museum.

(PLATE XI.)

TWO years ago if a Palæontologist had been asked to mention a region in Britain most barren of fossils, he might well have ected that great area of Central Wales which is marked by a sombre grey in the maps of H.M. Geological Survey. And even now, after my laborious search in that country, it cannot be said to be anything better than very poor in organic remains.

We have, however, now found a considerable number of specimens, and, what is more important, the species are quite sufficient to establish the exact age of the Cardiganshire group of rocks, and determine their order and succession. They belong to the Lower Llandovery period.

The most important of the fossils found belong to the group of *Graptolites*, of which I have already given an account with the kind help of Prof: Lapworth.[1] But there are other fossils and markings of great interest which have been reserved until now for description, although their names are already published. They form the subject of the present paper.

There has been some discussion of late[2] on the nature of such obscure markings as occur in the Aberystwyth grits, and perhaps the impression of many naturalists that they are of inorganic origin has been increased. Doubtless there are in the Cardiganshire rocks many markings of that nature, but the things I here describe are not such, but are structures of such distinct type and regularity of form as to leave no room for doubt of their organic nature.

The very ancient Foraminifera here described, and the fact of their close resemblances to modern forms, are also matters of particular interest.

The Aberystwyth rocks abound in extraordinary markings of concretionary or other origin, and great beds of rock have been re-made by these agents, but I find in most cases little difficulty in determining which of the peculiar structures are of organic origin and which are not.

Many even of the irregular concretions have had their first origin in some organic structure such as the position of a seaweed, or even the track of a worm; but these imperfectly marked structures I have not recorded in this paper, only describing the thoroughly well-marked types of whose organic nature there is no room for doubt.

## Description of Fossils from the Cardiganshire Group.

Plants.—The remains of plants are very conspicuous in the rocks of Cardiganshire, especially in the Aberystwyth Grits. In many cases we meet with the well-known difficulty of distinguishing between true plant structures and worm markings, but some of the vegetable remains are perfectly clear and indisputable, such as, for example, the various forms of fan-shaped Algæ of the Genus *Buthotrephis*.

Another type of vegetable structure is seen in the Net Algal (*Retiofucus extensus*, n. sp.), which consists of substantial bar-like structures, similar to bodies which are very generally referred to worm casts. The vegetable nature of this structure cannot however be doubted, as an inspection of the figure will show (see Pl. XI. Fig. 6), and it cannot possibly belong to the Annelida. We are thus prepared to receive other forms as vegetable remains, such as the *Palæochorda tardifurcata*, n. sp., whose general aspect is more worm-like. The last-mentioned species has indeed in itself sufficient evidence as to its real plant nature, showing here and there distinct branchings (Pl. XI. Fig. 5); but the ordinary specimens found would certainly be, by many Palæontologists, referred to worms. Thus I am led to regard most of the simple worm-like surface structures upon our Cardiganshire Grits as strap-like seaweeds.

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[1] Quart. Journ. Geol. Soc., May, 1881.

[2] Nathorst, Geol. Mag. 1882, p. 24.

It is noteworthy that these structures usually project as convex bodies upon the *under* surfaces of the Grit beds.

*Buthotrephis major*, n. sp. Pl. XI. Figs. 1 and 2.

Plant consisting of a long stalk of very uniform diameter, from the upper end of which springs an umbellate head or racemoid cone of branches. Branches usually 8—10 or more in number, mostly simple, but sometimes dividing dichotomously. The branches do not start from exactly the same point at the end of the stalk, though they all terminate nearly at one level, so that the structure is really corymboid; but the central axis may be so far developed that the head consists of a central rachis with lateral branches, pine-tree fashion (Fig. 2). Width of branches scarcely less than the main stem, very uniform throughout.

*Measurements of type specimen.*—Length of stalk, 2 inches; breadth of stalk, 1½ mm.; length of branches, 1½ inches; breadth of branches, 1½ mm.

Usually this species occurs as a delicate impression, or as half-compressed solid bodies in the Metalliferous Slate Series; but the plant has not unfrequently been buried upright, as it lived, in the sediment, when the circular sections and tip end of the branches come to resemble rain pittings.

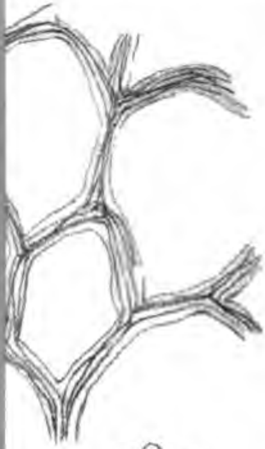
In the Aberystwyth grits of Craiglais, Aberystwyth, a group of more delicate narrow branched fan Algæ occurs, most of which probably belong to this species, their more scanty and delicate form being the consequence of less favourable life-conditions in the sands than in the clayey sea-bed.

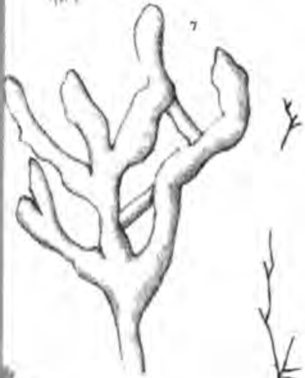
*Localities and Geological Horizon.*—In the Aberystwyth Grits and Metalliferous Slates at Craiglais, Aberystwyth; Llyn fron Goch, Llantrisant; Rhyd y Felin; Cefn Coch; S. of Tal y Bont; Pont Erwyd; Wern Grug, Llanilar road; Llanilar; Clarach; Talerddig; Tregaron; Pennant Valley, Llanbrynmaer; Machynlleth; East of Llan y Mowddwy.

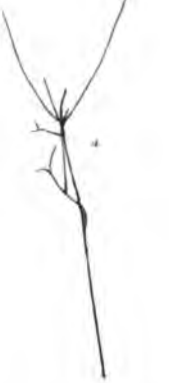
Also at Hodgson How Quarry, Keswick (?).

*Buthotrephis minor*, n. sp. Pl. XI. Fig. 3.

A stouter but smaller form than the last, and branching more freely. Stalk short and stout, giving off rapidly some two, four, or more main branches, which commonly divide once or twice again. A short irregular and expanded cone-head results, with the branches often fascicled. The branches are markedly smaller than the main stalk.







West Newman & Co. imp.

the *Chondrites* figured by M'Coy from the Skiddaw Slate; and some are worm markings.

Fragments similar to the *Palæophycus* (?) *striatus* of Prof. Hall, are not uncommon, and certain long square rods remind one of *Pal. simplex*, Hall. But I doubt whether these are organisms at all.

*Nematolites.*—These are curious irregular branching structures of widespread occurrence in Cardiganshire. They are always found as solid bodies of pale chocolate colour and earthy constituency, spreading out in a loose manner over the dark shales, from which they may often be easily isolated and mounted free of rock. Good specimens may be collected on Craiglais. With the magnifying glass and microscope no cells or other structures can be detected upon the surface, but some specimens show decided indications of a central axis. By preparing thin sections for the microscope this axis is shown to be only the dark argillaceous rock matrix, so that the original stem was fistular (see Pl. XI. Fig. 10); the thickness of the walls being less than the diameter of the interior of the tube. No minute structure is preserved in the walls.

I regard these bodies as forms of Coralline Algæ, the stems having been originally rigid and calcareous. It is probable that the *Nematolites Grayii* (Lapw.) of the Girvan district is of the same nature.

There appear to be two species in Cardiganshire.

1. *Nematolites Edwardsii*, n. sp. Pl. XI. Figs. 8–11.

Plant calcareous, branching, consisting of long wire-like cylindrical stems of uniform thickness (1 mm.), sometimes straight, but usually with irregular curves and twistings. Branches are given off in a most random manner, a stem often remaining perfectly simple for several inches and then giving off quite a bush of branches, or even forming a network. Still, the general build is very open and loose. The branches are of the same character as the main stems, and there is no perceptible diminution in their thickness. The included angle of division varies from an acute angle to a right angle; commonly it is very wide, *i.e.* nearly a right angle. Occasionally these branches coalesce or are bound together by a cross branch so as locally to form a network.

*Localities.*—In the Aberystwyth Grits and Metalliferous Slates at Craiglais, Aberystwyth; Ty Llwydd on the Rheidol; Devil's Bridge above Taliessin, Llantrisant, Dyffryn Castell, East of Devil's Bridge.

Similar bodies occur in the Arenig rocks of Barf near Keswick and Ellengill. See specimens in the Museum of Practical Geology, iv. 4. 42–44, called "branching Polyzoon." See also Salter in Quart. Journ. Geol. Soc., vol. xix. p. 137, fig. 14.

Also last year (1881) I found this structure in the grits of Hodgson How, Keswick, in a rock which is identical with the Aberystwyth group.

2. *Nematolites dendroidium*, n. sp. Pl. XI. Fig. 12.

Distinguished from the other species by having a distinct trunk and main stems, from which smaller lateral branches are given off.

These branches are usually dendroid, but occasionally they anastomose to form a network.

*Localities.*—Waun Nantydd Valley, between Trawscoed and Llantrisant; above Taliessin; in the Metalliferous Slates.

### *Foraminifera.* Pl. XI. Figs. 13–15.

The Rev. J. F. Blake first detected these organisms in the slates of Cwm Symlog, and published a note on their occurrence in the Geol. Mag. 1876 (Dec. II. Vol. III. p. 134). Mr. Blake writes: "The most perfect of these hollow casts could not be distinguished from that of *Dentalina communis*, and I could venture to name other forms, but with less certainty." Of these other forms I have succeeded in finding better specimens, which prove them to belong to the genera *Rotalia* (?) and *Textularia*. They occur as minute ochreous spots in thin pale slaty shales, either elongated (*Dentalina*) or rounded (*Rotalia*? and *Textularia*). On examining them with the lens, their camerated structures are perfectly clearly seen, the chambers being still hollow, and the original test, with the internal septal structures, replaced by an oxide of iron. From six to eight chambers are seen in the *Rotalia*, fifteen in the *Textularia*, and from five to nine in the *Dentalina*. The *Dentalinæ* are straight, or nearly so, but occasionally curved; their partitions are mostly oblique, but vary. Length from 1 mm. to 1½ mm.

It is remarkable that these forms of the *Foraminifera* are undistinguishable from our common living species. Mr. Blake has pointed out the similarity of the *Dentalina* to the living *D. communis*; the *Rotalia* and *Textularia* are also identical with recent shells of these genera. I therefore offer no new specific names for these earliest known types of our ordinary *Foraminifera*.[1]

## ANNELIDA.

### *Myrianites Lapworthii*, n. sp. Pl. XI. Figs. 16, 17.

A well-marked worm trail from Morben quarry, near Machynlleth. Only three specimens are known, two of them being upon the same slab of slate. They are coiled in parallel transverse curved duplicatures, which gradually diminish in length up to an apex, so as to produce that remarkable conoidal worm trail so well known in the Lampeter species figured in Murchison's "Silurian System."

The total breadth of the body is 5 or 5½ mm., consisting of an axial groove or body proper, and the impressions of the lateral feet on either side. The axial groove is a gentle depression, 2 mm. broad, and well defined. It is simple, or only slightly sinuous from the encroachments of the feet. Feet represented by gentle semicircular or oval prominences, continuous (in contact with one another), and alternating on the two sides of the body groove. Each foot is well defined, measuring 2 mm. broad, and from 2—3½ mm. in length. In some parts arched grooves cross the foot-markings obliquely from the front, dividing it into several (4) lobes. Cirrhi and setæ unknown.

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[1] *Foraminifera* occur also in the shales above the Bala Limestone at Guildfield, near Welshpool; and Mr. Davies of Oswestry tells me of others at Glascoed, near Llan y blodwell, Montgomeryshire.

The particular characters of the species are the proportions of the body and feet, and the shape of the latter. It is distinguished from *M. McLeayi* by its larger size and broader axis, and by its broad oval feet.

*Locality and Formation.*—Morben, near Machynlleth; in the Metalliferous Slate Series.

### *Orthoceras*, sp. Pl. XI. Fig. 18.

I have not been able to determine the species of this *Orthoceras*, for the shell itself is unknown, only internal casts being found. The more mature part of the shell is similar to *O. vagans* in its distant septa, but it tapers more rapidly. In the younger shell, on the other hand, the septa are closer set, and the shape is more cylindrical. Other cylindrical and slender Orthoceratites with distant septa also occur, and if all these belong to one species it must be very variable in form.

*Measurements.*—Length, 3 inches; breadth of broad end, 10 mm.; breadth of small end, 2½ mm.; breadth midway, 4½ mm.; distance between septa midway, 3 mm.; distance between septa near apex, 1 mm.

*Localities.*—Corys; Taren y Gesail; Melin Newydd Valley; Eglwys Fach; Cefn Hendre; and Steddfa Gurig.

### EXPLANATION OF PLATE XI.

Fossils from the Cardiganshire Group (Llandoveries).

Fig. 1. *Buthotrephis major*, Kpng., river side near Tal y bont.
,, 2. ,, ,, var. Llyn Fron Goch, Llantrisant.
,, 3. ,, *minor*, Kpng., Pont Erwyd.
,, 4. Algæ from Mynydd bach.
,, 5. *Palæochorda tardifurcata*, n. sp. Aberystwyth.
,, 6. *Retiofucus extensus*, n. sp. Cefn Coch, Aberystwyth.
,, 7. ,, ,, young form, Allt wen, Aberystwyth.
,, 8–11. *Nematolites Edwardsii*, n. sp. Aberystwyth.
,, 12*a*. *Nematolites dendroideum*, n. sp. near Llantrisant.
,, 12*b*. A part of same enlarged.
,, 13*a*. *Dentalina.*
,, 13*b*. The same magnified, Cwm Symlog.
,, 14. *Textularia*, magnified, Cwm Symlog.
,, 15. *Rotalia?* magnified, Cwm Symlog.
,, 16, 17. *Myrianites Lapworthii*, n. sp. Morben, Machynlleth.
,, 18. *Orthoceras*, sp. Taren y Gerail, S. of Cader Idris.

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## III.—Notes on the Permian and Trias.

By Professor Edward Hull, M.A., LL.D., F.R.S.,
Director of the Geological Survey of Ireland.

I WISH to make one or two observations on the Rev. A. Irving's paper on "The Permian and Trias," which has appeared in the Geological Magazine, and of which he has been so good as to send me a separate copy.

My first observation refers to the geological age of the Sandstone of the vale of the Eden, in which he quotes my name as a supporter of the view that it is of Permian age. Now, I wish to state, that personally I have never given an opinion to this effect, nor have I had any, but a very limited, opportunity of forming one. When it was announced some years ago by Sir R. I. Murchison and Professor Harkness, that the Upper Sandstones of the valley of the Eden, previously supposed to be Triassic, were in reality of Permian, age, I accepted their views with the reliance due to statements proceeding from such high sources. But as the evidence was rather of an inferential and indirect nature, I am quite prepared to fall back on Professor Sedgwick's views as soon as the officers of the Geological Survey shall have definitely pronounced in their favour.

I must, however, take some exception to the manner in which Mr. Irving has represented the respective positions of Sir R. I. Murchison and Professor Harkness in reference to this question. It is scarcely correct to say, that the former "manipulates the observations" and "overrides the previous judgment of the latter" as regards the age of the Upper Sandstones. As a matter of fact, Murchison and Harkness are equally responsible for the views expressed in their joint paper.[1] Murchison writes the "Introduction"—but all through the statements are made in the plural number, and are the result of their joint observations. Of this any one may satisfy himself by reference to the paper, and I think Mr. Irving was hardly justified in his way of representing the course taken by my former chief.

My next point is in reference to Mr. Irving's statements regarding the "Upper Permian" beds of South Lancashire. I very much regret that it betrays a hastiness of inference not to be expected of one who undertakes to review the whole question of the relations of British Permian and Trias. Starting with the statement that Mr. Strahan has "recently shown" that a certain duplex series of marls and sandstones which had been observed by Mr. Binney and myself to "crop out in one place"—and were supposed by them to be Permian—are really the base of the Triassic series in that district, he goes on to question the existence of Upper Permian beds in South Lancashire altogether. Now, in the first place, I beg to say that Mr. Strahan *has shown* nothing of the kind; and even if he had done so as regards the St. Helen's section, it would not have affected the general question of the existence of Permian beds in South Lancashire. The locality in question is at the extreme western limit of the district, and isolated from the main tract which ranges from Winwick to Manchester. Mr. Strahan's visit to South Lancashire must have been a flying one, in which he gathered up the most recent information from new sinkings, and if he had contented himself with giving the information thus acquired, without the generalizations in which he indulges, I would have had no objection to offer. But I must protest against such *ex parte* publication of views by an officer of the Survey made under such circumstances, in the face of those first arrived at by such a careful observer as the late Mr. Binney, who spent a lifetime in collecting evidence and formulating his conclusions thereon; and secondly, of myself, who spent several years in mapping this district officially, and had opportunities for observation and deduction which Mr. Strahan could not have obtained.

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[1] Quart. Journ. Geol. Soc. vol. xx. p. 144.

As a matter of fact, I have visited all the sinkings which he describes, and another which he does not describe, viz., one at Abram near Winwick, in which beds of calcareous marl with limestone bands are passed through below the New Red Sandstone, and from which I myself collected numerous small shells of Permian age of a kind which are to be found in these beds wherever they occur along the border of the Coal-field, such as *Schizodus*, *Turbo*, *Axinus*. etc., fossils which prove beyond question that these beds (as I have shown in one of my papers) are the representatives of the Magnesian Limestone of the North-east of England. These fossiliferous beds I regard as the equivalents of those referred to by Mr. Strahan, and nowhere do they occur in the New Red Sandstone.

I would ask Mr. Irving whether he has consulted the Survey Memoirs of the South Lancashire Coal-field, those of Prescot, Wigan, Bolton, Oldham, and Manchester, and of Stockport, and if so, whether he deliberately rejects the evidence therein detailed regarding the existence of these Upper Permian beds.[1]

Mr. Binney, who first determined the age of these beds, and had with admirable industry collected the details of every available section from Stockport on the east to Liverpool on the west, placed the question of their age beyond doubt, both by evidence of unconformity to the Trias above, and to the Carboniferous beds below, as well as by palæontological evidence.[2] On the question of the unconformity to the New Red Sandstone, the sections along the valley of the Mersey, depending partially on borings, and partly on visible evidence, first made out by Mr. Binney, and afterwards verified by myself,[3] is conclusive, even if it stood by itself. They show the Permian Marls with bands of limestone 129 feet thick at Heaton Mersey, the same at Hope Hill, only 25 feet, and at Stockport nearly absent, as the Pebble Beds of the Bunter rest almost directly on the Lower Permian Sandstone.[4] This overlap is from west to east, and shows that the Upper Permian Marls become thicker towards the Cheshire Plain, along the eastern side of the Coal-field, though the converse is the case on the Liverpool side.

As regards the general question dealt with by Mr. Irving, I am almost inclined to concur that there is but little evidence to support the view of a threefold division of the Permian beds. That there is a two-fold division I no less strongly hold; and if he will do me the favour to consult my paper "On the Evidence of a Ridge of Lower Carboniferous rocks under the Plain of Cheshire,"[1] he will see how I explain the differences in the mineral characters of the lower division as it occurs in the Midland Counties, and in the Northern.

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[1] Mr. Irving mentions the name of Mr. De Rance as a supporter of his views. This I can scarcely credit. At any rate he must excuse my accepting his unsupported statement.

[2] Contained in several papers but chiefly in the following, "On the Permian Beds of the North-west of England," Mem. Lit. and Phil. Soc. Manchester, vol. xii. A list of the fossils, and the general succession of the formations in S. Lancashire, will be found in the "Coal-fields of Great Britain," 4th ed., p. 198.

[3] "Geology of the Country around Stockport, Macclesfield, etc.," Mem. Geol. Survey, pp. 34-5

[4] Such thick beds of marl as those here stated nowhere occur in the Bunter Sandstone. I do not recollect throughout the whole of Lancashire and Cheshire even seeing a marly band more than about six or eight feet in thickness.

DUBLIN, 18*th Sept.* 1882.

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## IV.—NOTES ON THE POST-CARBONIFEROUS (DYASSIC) AND TRIASSIC DEPOSITS OF THE ALPS.

By the Rev. A. IRVING, B.A., B.Sc., F.G.S.;
of Wellington College.

THE purpose of this communication is to supplement the author's paper on the "Classification of the European Rocks known as Permian and Trias," which has appeared in recent numbers of this MAGAZINE. It is based on a short communication made to Section C. of the British Association at the recent meeting at Southampton, and has been expanded into the present paper at the request of the President of the Section, R. Etheridge, Esq., F.R.S.

Reasons were given in the former paper for not considering the names 'Dyas' and 'Permian' as altogether suitable as general terms applicable to the European area as a whole, since they severally connote the respective facies of the rocks of this age in particular areas. It is with geological history as with an imperfectly known country, one feels the desirability of great and distinctive land-marks; and such a land-mark is furnished for later Palæozoic times by the great Carboniferous system. The name 'Post-Carboniferous' was therefore proposed as a general term, and this name is here retained, until a better one is proposed, upon the high authority (among others) of Prof. Gümbel of Vienna as well as of that of Credner. It has been urged against the use of this term, that it applies to any and all of the formations which are later in time than the Carboniferous period. Such an objection is to my mind a feeble one; one might almost as well say that a 'postscript' to a letter includes all that the writer of the letter has since written. This, like so many other questions of nomenclature, cannot be settled by mere reference to a Latin dictionary: if it could be, a boy in a grammar school might perhaps decide it for us. One feels, and every one who has read Latin at all must feel, that in composition the prepositions acquire a flexibility which they do not possess to the same extent in their unagglutinated use. Surely 'post-' does sometimes mean 'coming after in importance' as well as in sequence of time; the term in question therefore implies that the series to which it refers, though having a sufficiently pronounced facies of its own to be entitled to be regarded as a system distinct from, is yet in some sense subordinated to, the Carboniferous system. Further, in considering the propriety of the use of the term now under discussion, it should be borne in mind that the strata, to which the name 'Post-Carboniferous' is here applied, are recognized as falling into the category of the Palæozoic rocks: the notion of their comprehension in this great series precedes therefore, and guides, our apprehension of the meaning of the term as it is here used.

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[1] Quart. Journ. Geol. Soc. vol. xxv. p. 171.

The main object of this paper is to draw attention to some of the latest results obtained by workers in Alpine geology, so far as they apply to our series: the results of the observations made by Gümbel, von Hauer, Mojsisovics, Emmerich, Zittel, Theobald, Pichler (not to mention others), should be better known than they are to the majority of English geologists. Maps published only a few years ago, in which a great portion of the limestone strata of the Alps was comprehended under the general name of 'Alpenkalk,' a name with which one is familiar in Cotta's "Die Alpen" (a highly suggestive work), and other writings of that period, are now practically obsolete for purposes of geological observation.

*Post-Carboniferous* (*Dyassic*) *Strata.*—On the northern side of the great east-and-west crystalline axis of the Alpine chain observations hitherto made seem to have failed to detect the presence of any very extensive deposits which can be referred to this system: the Triassic strata (according to von Hauer) follow at once upon highly metamorphosed rocks of Silurian age.[1] Von Hauer, however, includes certain deposits (Verrucano, etc.) among the Triassic strata, a proviso which must be borne in mind in comparing this statement with the dark streak which represents these deposits on his Map of Tirol, indicating their intervention between the crystalline and stratified series in N. Tirol. Further, a glance at the excellent Map of Switzerland by Studer and Escher von der Linth shows that, with the exception of these Verrucano deposits here and there, the Jurassic strata as a rule immediately succeed the crystalline rocks of the Central or Swiss Alps. In the southern zone the deposits thus far observed, which appear to be of Post-Carboniferous age, are comprehended also under the term 'Verrucano.' This may be defined as a series of grey and red-brown conglomerates and breccias, with red sandstones, and here and there coal-bearing strata. Von Hauer refers these to the lowest horizon of the Trias, but admits that they may with equal propriety be considered (in part at least) as belonging to the age preceding the Trias: Gümbel goes further, and recognizes in them the Alpine equivalents of the Rothliegende of Germany. The latter writer also points out that in places (*e.g.* in the Gailthaler Gebirge) limestone-strata containing marine fossils occur, which he considers to be comparable with the Zechstein, or at least with "strata recognized as of Dyassic age in the Nebraska region of North America."[2]

Accepting then the place assigned by Gümbel to the Verrucano and its associated deposits, we see that, as in the German and English areas, so in the Alpine area (or more correctly that portion of the earth's surface now occupied by the great Alpine mountain-system) the age of the Rothliegende was characterized by enormous volcanic activity. An example of this is seen in the extensive development of volcanic rocks (commonly known as 'quartz-porphyries'), which form the principal feature of the Bozen district. Here we find probably the most extensive display of such rocks which the present surface of the earth furnishes. The *eruptive* character of these 'porphyries' is clearly illustrated in the case of the Rittner Horn, the culminating peak of a district between the valleys of the Sarn and the Eisack known as the Ritten. Walking from Bozen to the summit of the mountain, and more especially in the upper part above Klobenstein, one passes in succession over alternating 'quartz-porphyries' (such as are extensively use for building purposes in Bozen) and ash-beds.[1] The stratification of these 'ash' deposits is brought out in the clearest possible manner by weathering, and frequently angular fragments (blown by steam along with finer débris from the ancient volcanic canal) are seen included in them: on the most highly weathered surfaces these fragments may be detached easily with a common alpenstock. In many cases a hand specimen (except on the point of hardness) could scarcely be distinguished from a specimen of tufa or peperino taken from the Roman hills, the colours of both these being here reproduced. The juxtaposition of the tuff-deposits and the ancient lava-flows may be frequently observed *in situ.* The summit of the mountain preserves the outline of a portion of the ancient crater, the remaining walls of which can be traced as distinctly as one can trace the remaining crater-walls of slaggy basalt of Tertiary age at Daun, or in the Moselberg in the Eifel. It would almost appear even that some of the beds were originally vesicular acidic lava-flows, and that the steam-cavities have been subsequently filled with quartz, perhaps (as M. Daubrée has taught us) by the action of super-heated water upon the siliceous materials of the rock. This hypothesis is, I think, warrantable, when we take into account the results obtained by M. Daubrée (especially *the deposition of crystalline quartz*) by heat from such a siliceous composition as we commonly call "glass," under sufficient pressure in mere super-heated water.[2] These Bozener volcanic rocks being in all probability of Dyassic age, the history of the Alpine mountain-system supplies ample data for the application of the physical principle so ably demonstrated by the great French savant.

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[1] *Vide* descriptive text of the *Geologische Uebersichtskarte der Oesterreichischen Monarchie,* Blatt No. 5, by Dr. Franz Ritter von Hauer.

[2] *Anleitung zu Geol. Beobachtungen in den Alpen,* von G. W. Gümbel.

The phenomena presented to us in this mountain seem to me to go altogether to confirm the view maintained by Prof. Credner, of Leipzig,[3] that the true place of these rocks known as 'quartz-porphyries,' in any system of classification of the crystalline rocks, is among the 'Older Eruptive Rocks,' and that they ought not to be included among the rocks called 'plutonic' as they are in Lyell's *Students' Elements.*[1] The mountain appears to be nothing more than an ancient 'stratified cone,' in the sense in which this term is used by the writer just referred to.

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[1] The earth-pillars ('Erd-pyramiden') of the neighbourhood are, or have been, severally capped with blocks of quartz-porphyry, but I think the finer materials which constitute them are more largely derived from the tuffs (clastic rocks) than from the crystalline rocks; both those of the Finsterbach near Lengmoos, and the group lower down near Bozen.

[2] *Vide Etudes Synthétiques de Géologie Expérimentale,* par A. Daubrée, pp. 165-6

[3] *Elemente der Geologie,* 3rd edition, pp. 274, 275.

It is on the margins of such districts as the Bozen volcanic region that the deposits known as Verrucano are commonly met with. In such a relation they occur (according to Gümbel) on Lake Lugano, in the Bündener Alps, in Windgälle, in the Mont-Blanc group, in Judicarien, in Val Lugana, near Cilly, and near Raibl. Since the above observations on the structure of the Rittner Horn were made by the writer two or three months ago, he has found the intimate relation in which the 'porphyries' are placed to the ash-deposits noticed by von Hauer.[2] The passage is worth quoting: "The oldest porphyries present (in the Bozen district) are younger than the clay-slates through which they have pushed their way, and upon the surfaces of which they are spread out, while the latest reach no further forward in time than the older Trias; since the tuffs, which on the one hand are placed in most intimate relation with the solid porphyries, pass on the other hand without any definite limit into the conglomeratic and sandy rocks of the Lower Trias." These 'Lower Triassic' strata of von Hauer are, as we have seen above, the strata referred by Gümbel to the age of the German Dyas, for the most part.

*Transition Beds.*—Of late the view has been propounded by some German and Austrian writers that the lower portions of the Werfener Schichten and the massive white limestone of Schwaz (in the Inn Thal) on the northern side of the Alpine chain, as well as the Grödner Schichten, the black 'Bellerophon Limestone' of the Puster Thal (abounding in Foraminifera), the Bröckel Dolomite, near Triente (rich in copper ore), on the southern side, should all be regarded as belonging to the upper horizon of the Dyas or Post-Carboniferous system. This view is controverted by Gümbel on the ground that the organic remains found in them do not give them "a pure Dyassic character, but very much more that of a transition series from the Dyas to the Trias." This, he points out, is particularly the case with the plant-remains recently found in the Grödner Sandstein at Neumarkt, near Bozen, and in the numerous recently-discovered fauna of the Bellerophon-Limestone of the Puster Thal. Of these remains the following are figured in his excellent little handbook before referred to.

*a. Plant-Remains from the Alpine Red and White Sandstones, and the overlying Grey and Calcareous Strata at Neumarkt:—*

*Æthophyllum Fötterlianum*, Mass.
*Voltzia recubariensis*, Mass., and *V. Messalongi.*
*V. Bröckhiana*, Heer, and *V. vicetina*, Mass.
*Carpolithes Hungaricus*, Heer, and *Carp. foveolatus*, Heer.
*Baiera digitata*, Heer.

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[1] Third edition, 1878, p. 557.

[2] *Ibid*, pp. 13, 14.

*b. Fauna of the Bellerophon Limestone:—*

*Bellerophon peregrinus*, Laube, and *B. Gümbeli*, Stach.
*Archeocidaris ladina*, Stach.
*Gervillia ceratophaga*, Schloth., and *Gervillia* (sp. ?).
*Avicula peracuta*, Stach., and *A. cingulata*, Stach.
*Pecten partulus*, Stach.
*Pleurophorus Jacobi*, Stach.
*Edmondia rudis* (?), M'Coy.
*Aucella Hausmanni* (?).
*Spirigera peracuta*, Stach.
*Turbonella* (sp. ?).
*Valvulina alpina*, Gümb.
*Endothyra radiifera*, Gümb., and *E. simplex*, Gümb.
*Trochammina vulgaris*, Gümb., and *T. crassa*, Gümb.
*Bulimina contorta*, Gümb.
*Lingulina lata*, Gümb., and *L. subacuta*, Gümb.
*Cythere oviformis*, Gümb., *C. navicula*, G., and *C. porrecta*, G.
*Kirkbya alpina*, Gümb.

In addition to the above, several forms of doubtful or at present undetermined genera are also figured, one of them being a doubtful form of *Anthracosia*.

The view taken by Gümbel, as to a 'transition series' between the Dyas and Trias occurring in the Alps, reminds one of the regular sequence of these strata in the German area, which was noticed in my former paper. It also brings to mind the way in which Mr. Twelvetrees tells us the Zechstein series in the Orenburg country is overlain conformably with sandstones and marls, apparently almost unfossiliferous.[1] The further investigation of both the Alpine and the Russian series seems therefore thus far to indicate that in these regions we may find the transition series which we know (on *à priori* grounds) must exist (or have existed) somewhere.

*Triassic Strata.*—What I have been able to observe during the past summer, added to the observations of former years, has impressed me more than ever with the profound truth of the remark by Prof. Credner, of Leipzig, that the true key to the geological history of Triassic times is to be found in the Alpine Trias.[2] The main results of the investigation of these strata, so far as it has proceeded up to the present, are given in the table at p. 500 of this paper. The chief authorities for it are von Hauer, Gümbel and Credner. It presents in one view both the stratigraphical order and the palæontology of the Trias of the Alps. It may be added that in the classification Gümbel (as representing the latest views) has been in the main followed, where he seemed to have good reasons for differing from von Hauer; but these differences are not of very great importance, except on the point to which reference has been already made, the geological age of the Verrucano. It will be seen that the three formations which constitute the German Trias have their equivalents in the Alps fairly well defined. The most noticeable thing about the distribution of the Triassic strata in the Alpine area is perhaps their absence, or at most their very feeble representation, in the Central Alps. It is only as we proceed eastward to the longitude of the eastern part of Lake Constance that we find any great development of the series; and this, progressing as we advance through the Vorarlberg, would appear to reach its maximum in the Salzburg country on the north side, and in the S. Tirol and West Venetian Alps on the south side, of the principal crystalline axis. The relations of these massive deposits, for the most part more or less of the character of limestones (their greatest development being either limestones, dolomitic limestones, or dolomites) to the more central crystalline rocks, have determined some of the most salient features of the orography of the Alps. Thus it is, broadly speaking, along the lines of strike of the Triassic strata that several of the finest and longest longitudinal valleys have been formed. Examples of this which at once occur to one are the Inn Thal (from Landeck to Schwaz), the Pinzgau, and the Enns Thal to the north, and the Puster Thal (the largest longitudinal valley of the Alpine chain) to the south of the crystalline axis. The splendid panorama presented to the view from the top of the Schmittenhöhe near Zell-am-See, shows very well the difference between the general physiography of the Triassic strata to the north, and the crystalline mountain masses (as represented by the Glockner Group) to the south. In a similar way the view from the top of the Rittner Horn enables us to make a comparison between the scenery of the beautiful region of the 'Dolomite Alps' in one direction, and that of the glacier-regions of the Ortler Group and the Oetz-Thal Group in the other.

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[1] *Vide* GEOL. MAG. Sept. 1882.
[2] *Vide* my former paper in recent Numbers of this MAGAZINE.

Lines of anticlinal curvature of the strata on a large scale (though quite subordinated to the principal anticlinal of the whole chain) may be distinctly observed in places. Such an anticlinal for example is seen to extend through the upper part of the Grödner Thal by Cortina in the Ampezzo Thal to Piave di Cadore. In this line of valley two principal passes are crossed; and since neither of these is of sufficient elevation to be covered with glaciers, the structure of the valley along the whole line is easily observed. Instances in which there is such a clear connexion between the direction of a valley and a line of weakness amounting to actual *fracture*, along an anticlinal axis, are perhaps not often to be met with. Of course in this case the grass-grown floor of the valley, through the greater part of the line, leaves the origination of the valley to be inferred from the unmistakable dip in opposite directions, not only of the massive limestone strata, but also of the more thinly stratified Wenger Schichten and Bunter strata, which are seen in places dipping into the mountain-side beneath the dolomitic masses, which constitute the often grotesque elements of the scenery of the region; but on the passes the evidence is a matter of more direct observation. This is especially so in the case of the Grödner Joch, at the head of the Grödner Thal. The Pass itself is a rather sharp saddle, in the lowest part of which the strata are clearly exposed to view on both sides of the footpath, and the actual line of fracture of the beds is visible. The accompanying sketch (Fig. 1) will make this more clear (see p. 502).

# OUTLINE TABLE OF THE ALPINE TRIAS.

## UPPER TRIAS (=GERMAN KEUPER.)

["Palæontologically considered these form a continuous whole, since the fauna of the lower stages does not differ essentially from that of the upper, and if the fauna is marked by considerable enfeeblement in the middle stages, this is to be ascribed much more to the influence of different conditions of life than to difference of age" (von Hauer).]

9′. *Upper Dachstein Limestone.*—Grey and white limestone, characterized by ***Megalodus triqueter*** **("Dachstein-bivalve") and banks of Corals,** ***Lithodendron*** *(Rhabdophyllia) clathrata*, and *L. rhætica*, with deep-sea Foraminifera. In the interior of the **northern Alps forming the rugged masses of the Tännen-, Dachstein-,** Todten-, Watzmann-, Stein-, and Reutalp-gebirge.

9. *Rhætic Beds* (proper), including the 'Kössener Schichten,' mostly marly **deposits rich in fossil-remains:** ***Avicula contorta, Cardium Rhæticum, Pecten Valoniensis,*** *Terebratula gregaria, Spirifera uncinata, Gervillia inflata, G. præcursor,* ***Ostrea intusstriata, Myophoria postera, Ostrea Haidingeriana, Terebratula norica,*** *Anomia alpina, Rhynchonella fissicostata, Spirigerina oxycolpus, Mytilus minutus.*

8. *Hauptdolomit* (passing into the 'Plattenkalk' and the 'Lower Dachsteinkalk' of Gümbel). **A finely granular distinctly stratified dolomite, developed to** such enormous proportions that it forms vast mountain masses in the German and North Italian Alps. **Poor in fossil-remains, but produces here and there a few** traces of fishes (*Semionotus, Lepidotus, Pholidophorus*). *M. triqueter* characterizes the more calcareous portions. ***Dicerocardium Jani, Avicula exilis, Turbo solitarius, Rissoa alpina,*** *Cerithium Gümbeli*, and *Gyroporella vesiculifera* also occur according to Gümbel.

| IN THE FASSANA AND WEST VENETIAN ALPS, THE SO-CALLED 'DOLOMITES.' | IN BAVARIA, NORTH TIROL, VORARLBERG AND SALZKAMMERGUT. |
|---|---|
| 7. *Raibler Schichten* (=Upper St. Cassian Beds of Gümbel), including the Oolitic, calcareous, and sandy strata of the Schlern Plateau: fossils, ***Myophoria Kefersteini,*** *Perna aviculæformis, Corbis Mellingi, Ammonites* ***floridus, Corbula Rosthorni,*** *Myophoria Whatleyæ, Anoplophora Münsteri* (the chief characteristic fossil of the Lehrberg strata in the German Keuper, allied if not equivalent to the *Myacites* of England, Etheridge), ***Pecten filosus,*** *Halobia rugosa, Cardita subcrenata, Nucula sulcellata, Solen caudatus.* | **7′. *Cardita crenata Group.*—These form a definite group of strata extending through Vorarlberg and the Eastern Alps, according to Credner, who considers it as comprehending:—**<br>**d. Rauchwacke with gypsiferous shales, passing upwards into the Hauptdolomite.**<br>**c. Cardita Beds (proper), Oolitic strata full of *C. crenata* and other bivalves, including *Pecten Helli, Corbis Mellingi, Corbula Rosthorni, Ammonites floridus.***<br>**b. Lunzer Sandstein, greenish-grey micaceous sandstones containing plant-remains (and even workable coal-seams towards the east), of which the chief are: *Pterophyllum Jägeri*, and *Pecop. Stuttgartiensis.***<br>**a. Halobia Shales, with *Halobia rugosa*, and *Ammonites floridus.*** |
| 6. *Schlern Dolomite.*—A massive crystallo-granular dolomite (more than 1000 mètres thick in the Schlern Mountains), forming by its erosion and | **6′. *Wetterstein Group.*—An unusually massive development of white limestone, and whitish dolomites, Oolitic in places, forming the lofty *massiv* of the** |

5. *St. Cassian Beds* (Lower St. Cassianer Schichten of Gümbel).—Volcanic ash interstratified with marls and Oolitic marly limestones, with an extraordinarily rich Fauna containing 37 species of *Ammonites*, 3 of *Orthoceras*, 205 Gasteropods, 70 Acephalæ, 33 Brachiopods, 29 Echinidæ, 10 Crinoids, 42 Corals, 36 Sponges. Of these the more common are as follows: *Cidaris dorsata*, *C. alata*, *Ammonites Aon*, *A. Jarbas*, *Orthoceras elegans*, *Bactrites undulatus*, *Neritopsis ornata*, *Cardita crenata*, *Monodonta Cassiana*, *Nucula lineata*, *N. strigilata*, *Cassianella gryphæata*, *Avicula Gæa*, *Koninckia Leonhardi*, *Pentacrinus propinquus*.

limestone masses about Berchtesgaden, Hallein, and Aussee in addition to those of Hallstatt.

Marls (with St. Cassian fossils) are interstratified with the white Wetterstein Limestone: fossils, *Encrinus Cassianus*, *E. propinquus*, *Terebratula indistincta*, *Cidaris dorsata*, *C. Hausmanni*.

5'. *Partnach Beds.*—Dark-coloured (often micaceous) marl-slates and shales, and dark shaly limestone (occasional hornstone), with sandstone in the Upper strata: fossils, *Calamites* (*Equisetum*) *arenaceus*, *E. columnare*, *Pterophyllum longifolium*, *Neuropteris remota*. (These are considered by Gümbel equivalent to the Lower Keuper.)

## MIDDLE TRIAS (=GERMAN MUSCHELKALK).

['Augite-porphyries' (including porphyrite, diabase, and melaphyre) occur as eruptive rocks with their accompanying tuffs in several places, and in enormous proportions in the Fassa-Thal, to mark this horizon.]

4. *Wengener Schichten.*—Thin-bedded dark-coloured limestones, passing up into dark-coloured shales (indurated), siliceous limestones, and volcanic ash; containing *Halobia Lomelli*, *Posidonomya Wengensis*, *Encrinus Cassianus*, and numerous Ammonites, including *A. Aon*.

3. *Wellenkalk Group.*—Under this term are included the Virgloria Limestone, the Recoaro Limestone, and the Raibling and Gössling Beds; bitumen and silica often occur, as well as layers and nodules of hornstone. In S. Tirol a massively-bedded dolomite (Mendola Dolomite) occupies this horizon over a considerable area. Fossils, *Rhynchonella decurtata*, *Terebratula vulgaris*,* *Spiriferina Mentzeli*, *Ammonites binodosus*, *A. Studeri*, *Pecten discites*,* *Lima striata*,* *Gervillia socialis*,* *Myophoria vulgaris*,* *M. cardissoides*, *Natica gregaria*, *Amm. Dux*, *A. luganensis*, *Dadocrinus gracilis*, *Encrinus liliiformis*.

2. *Campiler Schichten.*—Similar to No. 4, with interstratifications of yellow dolomite, containing *Pleuromya Fassaensis*, *Avicula Venetiana*, *Gervillia costata*, *Myophoria ovata*, *Naticella costata*, *Turbo recticostatus*, *Holopella gracilior*, *Pleurotomaria triadica*.

## LOWER TRIAS (=GERMAN BUNTER).

[These include the principal gypsiferous strata and part of the saliferous strata of the Alps. Petrographically, and in poverty of organic remains, they agree with the Bunter elsewhere.]

*Buntsandstein Formation.*—Forms the true basis of the limestone series in the interior of the Alps; well exposed in the Grödner Thal (about S. Ulrich and in the Seisser Alp), and in the Etsch Thal. Includes the 'Werfener' and 'Guttensteiner Schichten' of von Hauer, the 'Grödner Schichten' of Richthofen, and the 'Seisser Schichten' of Wissman. Most characteristic fossils: *Myophoria costata*, *Posidonomya Claræ*. (In attempting to indicate the limits of this formation Gümbel has been followed; it should be borne in mind, however, that considerable difference of opinion exists as to its vertical limits both upwards and downwards. What is here given is provisional and tentative. The subdivision into 'Röth' and 'Hauptbuntsandstein' seems of little value.)

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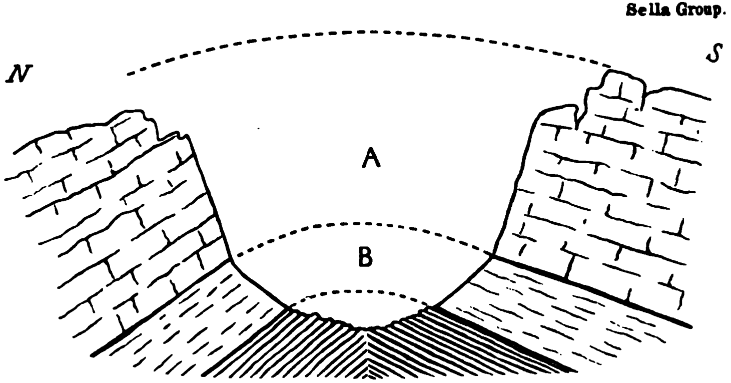
* Common to these Alpine strata and the German Muschelkalk.

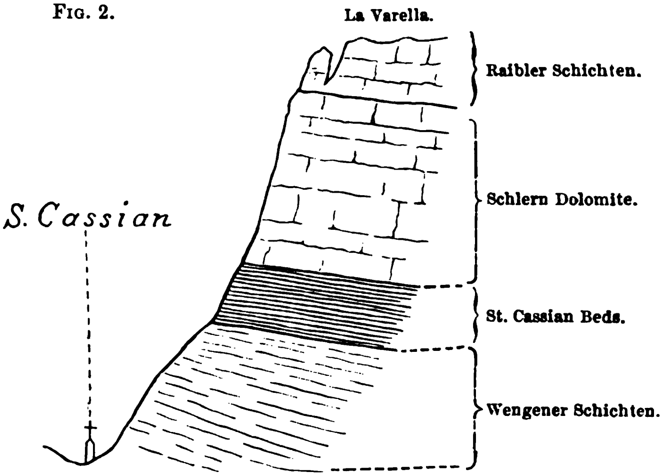
FIG. 1. Section across the Grödner Joch showing anticlinal fracture.



Wengener Schichten.
A. Schlern Dolomite. B. St. Cassain Series.

On the pass Valparola, the contrary dip of the beds is just as clearly seen, though the erosion has only proceeded down to the St. Cassian Beds. For the last hour or so of the ascent to this Pass one walks over the débris of these beds, and meets with plenty of detached blocks of the strata to impress one with their highly fossiliferous and often oolitic character. Looking down from the Pass into the valley beneath, with the village of St. Cassian lying below, the structure of the valley can be clearly seen as the eye traces the strike of the several series of strata in the side of the mountain. Subjoined is a section of one side of the Valley of St. Cassian. (Fig. 2).

FIG. 2.



The Raibler Schichten and Schlern Dolomite are seen in the neighbouring peak of Heiligkreuz passing underneath the Hauptdolomite. *Megalodus Triqueter* (in casts) abounds in these Upper Limestone strata.

A walk of two or three days through the Grödner Thal and on to Cortina offers an excellent study of a considerable portion of the Alpine Trias. Leaving the deep gorge-like valley of the Eisak, which presents us with splendid sections of the volcanic series, we find ourselves during the first part of the ascent of the Grödner Thal down among the metamorphic rocks. As we ascend the valley mounting up enormous heaps of moraine débris, we come again among the volcanic series. The enormous dimensions of the blocks of quartz-porphyry and altered ash which make up these moraine-heaps is astonishing even to one who has seen a good number of moraines in other parts of the Alps. Here and there the sides of the valley are seen falling back into gentle curves, suggesting the incipient stage of the formation of *cirques* by the weathering away of rocks with transverse planes of weakness. The principal moraine, as it now appears, seems to explain the existence of a quondam lake, which some six centuries ago is said to have filled all that part of the valley in which S. Ulrich now lies. In the neighbourhood of this thriving village (the 'Hauptort' of the 'Gemeinde') the Verrucano may be very well observed. On mounting up the steep ascent from St. Ulrich to St. Jakob a capital study of the Bunter series is offered. These strata abound here in gypsum, and are in places fossiliferous, *Posidonomya Claræ* being rather abundant. The scenery along the line we have defined includes the magnificent Sella Group, and further to the east the Trai Sassi, Tofana, the Cinque Tori, Serapiss, etc. The rest may be gathered from the sections described above. What has been here said of a particular district affords a fair sample of the 'Dolomite Alps,' which occupy an extensive region extending eastward from the Eisak Thal and southward from the Puster Thal. The almost unique scenery of the region seems to result from (1) the nearly horizontal lie and position of the major portion of the dolomitic strata; (2) the almost vertical weathering through of the beds, partly as a consequence of (1); (3) the splintery fracture of many of the hardest and most compact beds; (4) the interbedding of marly deposits with the dolomitic masses.

In North Tirol the scenery, though not generally so striking as that of South Tirol, rises however to a high degree of grandeur. This, with the Salzburg country, is *par excellence* the region of *valley-lakes*, a very considerable number of which lie *among the limestone strata of the Alpine Trias.* The boring through these strata in the Vorarlberg Tunnel now in progress from Landeck to Bregenz, will doubtless throw much light on the succession of the series in their more western development. An example of the enormous extent to which these strata have in places undergone dislocation is presented to us in the Achensee. This beautiful lake appears to lie in a line of fault, the throw of which must be 4,000 to 5,000 feet. The evidence of this, so far as I have been able to observe it, is the dip of the strata at a high angle, on the west side from the lake, on the east side towards the lake, coupled with the fact that while the Triassic Limestone strata strike north and south along a steep mountain-face on the western side, the slope of the valley above the lake on the eastern side of it, which is roughly-speaking parallel with the general dip of the strata, is composed of what appear to be strata of the horizon of the Dachstein series, abounding as they do with huge Corals of the genus *Rhabdophylla* (*Lithodendron*), which are characteristic of this horizon. This view of the structure of the valley is confirmed, when one ascends the Unnutz or the Hochiss, which rise above the Achensee on the east side, and gets a view of the strike of the strata, repeating those of the eastern side of the lake. Further, if this be the true explanation of the formation of this lake-basin (a view which is strengthened by the fact that the pass at Maurach at the southern end of the lake is not more than 40 feet above the level of its waters), it serves perhaps to explain why this lake, which is said to be 2,500 feet in depth, fell 4 feet during the great Lisbon Earthquake in 1755, and remained at that lower level for some 24 hours.

The section of the mountain-face above St. Cassian representing a thickness of more than 4,000 feet, which has been given above, may be compared with a typical section (after Mojsisovics) of the Triassic strata in the northern Alpine zone. This is drawn through the mountain-mass which rises above Saalfelden, and terminates in the rugged peaks and huge crags of the Steinernes Meer, the profile of which must remind an observer of the scenery of the so-called 'Dolomite Alps.' The section (which is given in Credner's text-book, fig. 273) is as follows:

| | | |
|---|---|---|
| *i.* | 'Dachsteinkalk' | Rhætic. |
| *h.* | 'Korallenkalk' | |
| *gd.* | Dolomites of the Cardita-Schichten | Lower Keuper. |
| *g.* | 'Cardita-Schichten' | |
| *f.* | White 'Wettersteinkalk' | |
| *e.* | Red 'Plattenkalk' | |
| *d.* | 'Virgloriakalk' | Muschelkalk. |
| *c.* | Dark-coloured Limestone | |
| *b.* | 'Rauchwacke' and dark-coloured Limestones | Bunter. |
| *a.* | Red 'Werfener Schichten' | |

Figures 55, 56, 57, 58 in Gümbel's "Anleitung" give also well-chosen sections illustrative of the Alpine Trias.

To get a clear idea of the palæontology of the Alpine Trias, a visit should be paid to Prof. Zittel's splendid collection in the Munich Museum. The 'Klipstein Collection' in the Museum of Natural History at South Kensington requires yet many things to be added to bring it up to the completeness of Zittel's, which is perhaps the finest and most complete collection of the fossils of the Alpine Trias in the world.

The Triassic period was marked by the exhibition of considerable volcanic energy in the Alpine area. The eruptive rocks of this age are chiefly composed of augite-porphyry (*e.g.* in the Seisser Alp), melaphyre (cutting through not only the strata of the Lower Trias, *but* even sometimes the augite porphyries themselves; *e.g.* about

Predazzo), monzonite, tourmaline-granite, and porphyrite. These are found, as well as the 'quartz-porphyries' of the Dyas period (cf. *supra*) very commonly associated with interbedded tuffs and with contact breccias. As a natural consequence, the calcareous and dolomitic strata are often altered into a coarsely crystalline marble, while crystals of garnet, vesuvian, and spinel are developed in places by contact-metamorphosis.[1]

Upon the whole, it would appear from the most recent observations that even in the Alps the distinction between the Post-Carboniferous (Dyassic) and Triassic systems is not very clearly defined, so far as any actual boundary-line is concerned: special importance from this point of view seems to attach to the views of Prof. Gümbel, to which reference has been made above, as to the *transition character* of the Bellerophon Limestone of the Puster Thal and the Sandstone series (with plant-remains) near Bozen. Anything like confident assertion on this matter would however be at present premature: we must await the results of further observations, results for which doubtless a few years will suffice to the many competent observers, who wend their way every summer from the universities and academies of Germany and Austria to the regions of the High Alps.

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## V.—SUPPLEMENT TO A CHAPTER IN THE HISTORY OF METEORITES.

By WALTER FLIGHT, D.Sc., F.G.S.

(*Continued from p.* 452.)

### 1853.—Tazewell, Claiborne Co., Tennessee.[2]

Brezina points out that in the Catalogue prepared by Tschermak[3] this iron is indicated as *Of*, showing fine-ruled Wiedmanstättian figures. It differs, however, very much from other irons of this group, like that from Lion River, Jewell Hill, Charlotte Co., etc., while it closely resembles the Butler iron. While, however, in the latter case the chief walls of the skeleton inclose very large chambers, here they are very small, so that the skeleton-character is far less marked. The characteristic of the two irons of Butler and Tazewell rests mainly on the very unusual smallness of the octahedral lamellæ, whereby the beam-iron, or its representative, almost vanishes, the irons consisting almost entirely of interstitial and band-iron (and of troilite inclosed in both, and schreibersite plates in Tazewell). Whether the almost infinitely thin nucleus of the lamellæ is identical with the ordinary beam-iron can only be decided by further investigation. The appearance of traces of granular structure renders it very probable.

### Found 1858–59.—Staunton, Augusta Co., Virginia.[4]

In 1871 Mallet described three masses of meteoric iron which had been found near Staunton; another has now been brought to light, and examined. It was found by a negro in 1858 or 1859, who brought it to Staunton, and endeavoured to sell it. He failed to do so, and threw it away behind a blacksmith's shop, where it lay several years until it was used with other loose material to build a stone fence. By reason of its irregular shape and great weight it soon fell out of the fence, and was next used by a dentist as an anvil, on which to hammer metal plates, and for such base purposes as the cracking of nuts; then it was again built into a wall round the curbing of a cistern. In 1877 it was removed to Rochester, N.Y., and a fragment of it came into Mallet's possession. It weighs 152 pounds, is 45·7 cm. in length, and 29·2 cm. in breadth, and in shape somewhat resembles that of a shoulder of mutton. A sketch of the mass is given in Mallet's paper. The specific gravity of the iron is 7·688, and the metal, when etched, exhibits the Wiedmannstättian figures "clearly and beautifully." The composition of the iron was found to be:—

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[1] Credner: *El. der Geol.* p. 531.

[2] A. Brezina, *Sitzber. Akad. Wiss.* 1880, lxxxii. Oct.-Heft.

[3] *Mineralog. Mitth.* for 1872, 165.

[4] J. W. Mallet. *Amer. Journ. Science*, 1878, xv. 337.

| | |
|---|---|
| Iron | 91·439 |
| Nickel | 7·559 |
| Cobalt | 0·608 |
| Copper | 0·021 |
| Tin | trace |
| Phosphorus | 0·068 |
| Sulphur | 0·018 |
| Chlorine | trace |
| Carbon | 0·142 |
| Silicium (reckoned as silicic acid) | 0·108 |
| | 99·963 |

There can be no doubt that the four specimens found in the same neighbourhood represent different portions of the same meteoric fall.

### 1861, June 28th (June 16th, O.S.), 7 a.m.—Grosnaja (Grosnja), Banks of the Terek, Caucasus, Russia.[1]

Sixteen years ago Abich, who was at the time in Tiflis, sent to Gustav Rose, in Berlin, a short description of a large fall of meteorites at Grosnaja on the morning of the above day. The greater number appear to have fallen into the river Terek; one fell in the great square in the interior of the (? Staniza) barrack, entered the ground to the depth of 1¾ feet; it pursued an oblique course through the air, and was distinctly warm when dug out. The meteorite had the form of a huge hailstone, and was covered with a black crust.

Abich, who had taken up his residence in Vienna, placed the stone in the hands of Professors Tschermak and Ludwig for examination, and the results of their investigations, together with a detailed report of the circumstances attending its descent, have been incorporated in the paper by Professor Tschermak, referred to in the note.

It is stated in the report drawn up by General-Major Kundukof, military commandant of the Tschetschensk district, that on the night of the 15th-16th June (O.S.), a barely dark one, there was neither thunder, wind, nor rain. On Friday, the 16th, the morning was clear and bright; light rain-clouds, which however brought no rain, hung on the western horizon over the station Mekenskoi, the inhabitants of which were startled at about seven o'clock by a deafening sound, which continued a long space of time. A non-commissioned officer of the Mosdok regiment, who was walking from the Navursky to the Mikenskoi barracks (? Staniza), noticed that the sound appeared to come from the west, where the rain-clouds were, and describes it as resembling that produced when many cannon are fired simultaneously, followed by a deafening noise like that caused by battalion-firing. He observed the fall of one of the stones, which descended at a low angle, and it was accompanied by lateral bands of a bluish colour (welcher von Nebenstreifen von blaülicher Farbe begleitet war). It fell in the court-yard of a house about two paces distant from a summer-house, and thirty paces from the bank of the Terek. A soldier's wife, standing on the threshold of the house, drew back in the greatest alarm as the meteorite struck the ground two paces from her with all the violence of a bomb-shell, scattering the earth over the wall of the house. A soldier soon probed the hole with a ramrod, and found at a depth of rather more than a foot fragments of the stone weighing in all ten pounds. Many heard a second sound, as though the meteorite burst twice in its descent through the atmosphere, and the noise attending the fall was observed by persons eight versts distant on the other side of the Terek. A woman who was occupied in washing clothes, at a spot about 1050 feet distant from the point where the meteorite struck the ground, heard fragments, which had been detached by the explosion, fall into the river Terek. The water fizzed just as it would when brought in contact with a large quantity of heated iron.

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[1] G. Tschermak, *Mineralogische und petrographische Mittheilungen*, 1878, 153.

The meteorite has a longish rounded form, and has lost the greater portion of its crust; in fact, the crust, together with a thin layer of the inclosed silicate, is very easily removed, and probably dropped off at the time of the fall. Its actual thickness is much greater than in the case of the stones which fell at Knyahinya, and about as thick as that of the Pultusk aërolites.

Professor Tschermak goes on to describe the Vandal treatment to which the stone was subjected before it reached his house for investigation. A cast of it had been taken for the Academy of Sciences of St. Petersburg, and it had subsequently been sawn in two. It appears, in the first place, to have been rubbed down with fat, not oil even, and, after the mould was taken, to have been soaked with potash lye to remove the unctuous layer; the carbonate of potash, which penetrated the porous stone with scarcely any crust to protect it, next began to effloresce, and the new danger to which it was exposed had to be compassed by drenching it with water. It was now ready to pass from the clumsy hands of the modeller to experience the yet more tender mercies of the lapidary, who, not to be outdone by his fellow-workman, it is to be conjectured, proceeded to close all the fissures and lines upon its surface with a black varnish. Long treatment with alcohol and protracted drying in a steam bath were the next operations which were made with a view to cleanse it.

A system of cracks and fissures, arranged like the branches of a tree, traverses the whole stone, and gives us the impression that they are the result of the blow which the meteorite received on its fall. The mass of the stone is brittle, the colour blackish grey with bright points. There are many inclosed mineral particles, some almost invisible, others 1 cm. across, the greater part having a diameter of less than 2 mm. The matrix is black and opaque even when viewed in a microscopic section, and many of the inclosed particles are opaque or only translucent in points. Most of them, however, are transparent, and the majority have a circular or rounded outline. A plate is appended to Tschermak's paper showing figures of the inclosed minerals. Five distinct ingredients could be distinguished. The first is a clear greenish mineral, with incomplete cleavage along two directions perpendicular to each other, and identified as olivine. A second in round tough spherules, brownish in hue and not numerous, with a finely foliated or finely fibrous structure, was found to be bronzite. Inclosed particles are sometimes made up of these two minerals, sometimes, but not very frequently, of them together with a third silicate in long greenish prisms which have the appearance and angles of augite. The meteorite also contains some magnetic pyrites (troilite?), a very little nickel-iron and perhaps a little carbon, to which the dark hue of the matrix is due.

Tschermak directs attention to two peculiarities observed in several chondritic meteorites, and noticeable in this one. The first is the occurrence of a crust over the surface of the bronzite spherules, possessing fibrous structure. This crust is thin, and is distinguished from the inclosed material by its paler colour; it has the same fibrous structure, doubly refractive power, and, in fact, is optically orientated like the inclosed silicate. It appears to be produced by some agent acting from without, perhaps heat in conjunction with a reducing gas. The agent has not caused fusion, but a slight modification of the texture of the surface. The second point which he has observed is the distribution in zones of the magnetic pyrites in many of the granular inclosed masses. When a microscopic section is examined by reflected light, it is found that many are apparently surrounded by a crust of the metallic sulphide, in others it occupies the centre of the mass, in all cases apparently filling up interstices. It seems as if the sulphide had impregnated the rocky mass, and the absence of all magnetic pyrites in the very compact inclosed particles, and the tough fibrous bronzite chondra, confirms this view. This impregnation Tschermak believes took place after the inclosed mineral particles attained their present form, and the only explanation which can be suggested is that this must have happened while the whole tufaceous mass was strongly heated. According to this theory, the inclosed granules coming in contact with fused magnetic pyrites must have drawn it into the fine fissures and interstices, in some instances into the cavities of the granules themselves.

This argues the existence of two definite stages in the formation *of these* and similar chondritic structures. First, the production of the olivinous tuff by the splitting and attrition of the rock when the tougher particles are rolled and rubbed together till they have a roundish or spherular form; and secondly, a subsequent application of heat to the tuff, accompanied not unfrequently by the reducing action of gases and vapours.

The Grosnaja meteorite appears to consist of—

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| Silicic acid ... ... ... ... ... ... | 33·78 |
| Alumina ... ... ... ... ... ... | 3·44 |
| Iron protoxide ... ... .. ... ... | 28·86 |
| Lime ... ... ... ... ... ... ... | 3·22 |
| Magnesia ... ... ... ... ... ... | 23·55 |
| Potash ... ... ... .. ... ... ... | 0·30 |
| Soda ... ... ... ... ... ... ... | 0·63 |
| Carbon ... ... ... ... ... ... ... | 0·68 |
| Hydrogen ... ... ... ... ... ... | 0·17 |
| Magnetic pyrites ... ... ... ... ... | 5·37 |
| | 100·00 |

Olivine appears to be the prevailing silicate in the meteorite; in addition to bronzite there appears to be a little augite and felspar, although their presence could not be recognized. We find, moreover, a small amount of a carbonaceous ingredient, to which, as well as to the magnetic pyrites, the blackish grey colour of the matrix is probably due.

A plate showing six sections of the mineral constituents of this meteorite accompanies Tschermak's paper.

(*To be continued.*)

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## VI.—TRACES OF A GREAT POST-GLACIAL FLOOD.

### 4. EVIDENCE OF THE ANGULAR DRIFT.

By HENRY H. HOWORTH, F.S.A.

(*Continued from the October Number, p.* 440.)

LET us see then what "the Old Masters" had to say on the subject before us. In Mantell's Geology of the South-East of England, 1833, page 28, speaking of the beds of slightly rolled flints which occur on the Downs in Sussex just underneath the turf, he says, "The flints are more or less broken, have suffered but little from attrition, and are so abundant as to form a constant supply for repairing the roads in the south-eastern part of Sussex. This bed has clearly been formed by the destruction of the upper portion of the chalk; and it is equally evident that the cause which produced the disintegration of the *superior strata was as transient as it was effective,* since, although the chalk in which the flints were imbedded has been entirely destroyed, the latter have sustained but very little injury."

In 1839 Sir Henry De la Beche published his masterly report on the Geology of Cornwall, Devon, and West Somerset. In this admirable work he discusses *inter alia* the origin of the gravels and other superficial detritus in which stream-tin occurs. He argues strongly against the marine or fluviatile origin of these gravels. Speaking of the valleys in which they occur, he says that if, previous to the drift of the tin-stone pebbles, they had been beneath the sea, and exposed to the action of tides and currents transporting detritus, we should expect, in accordance with the effects now produced by such agents, that they would become more or less filled up by drifted substances; and, if they were valleys above the level of the sea, as they now are, that the usual drift of transported matter would have partially covered their lower parts in the manner we now see. "If," he adds, "the stream-tin occurred in frequent layers, and was irregularly dispersed in the mass of detritus now found in the valleys containing it, it might be supposed that rivers, running over ground traversed by strings or lodes of tin, brought down pebbles of tin ore when in flood, distributing them here and there according to circumstances, while at other times they merely carried forwards the ordinary and less ponderous detritus. So far from the tin-stones being thus dispersed through the mass of gravels and sands in the valleys containing them, we find the pebbles at the base of the whole, resting upon the subjacent rock, commonly termed the *shelf*, forcing their way, particularly when the tin-stone grains are fine, into all the chinks and crevices on its surface. . . . . The stream-tin is always, moreover, found in greater abundance where we may suppose that eddies would be produced in a body of water pouring down the stanniferous valleys, these having the general forms they now possess. It appears as if any previous detrital contents of the stanniferous valleys, should such contents have existed, had been fairly washed out by a *mass of water rushing over the land, rolling and driving various loose materials before it*, and allowing the tin-stone from its greater specific gravity to be strewed along the bottom, where circumstances permitted. If we regard the surface of Cornwall, on which a crust of decomposed or disintegrated rock now exists, one arising from the action of atmospheric influences, *and imagine a body of water to rush violently over it, carrying this disintegrated or decomposed surface before it down the present valleys*, stream-tin would be found distributed in them much as it has been hitherto discovered. . . . . It will be readily seen that the tendency of the tin-stones to come to rest, from diminished velocity in water capable of transporting all these substances, would be far greater than that of the other mineral bodies usually occurring as gravel with it, all other circumstances being equal. When, therefore, a transporting water could no longer carry tin-stones onward, it would be capable of pushing forward or retaining in mechanical suspension the other gravel associated with it; so that a fundamental layer of tin-stone pebbles might be accumulated at the bottom of a valley, and remain settled, while lighter bodies were driven or carried over it, due allowance being made for the forms and volumes of the component parts of the whole transported detritus, tin-stone pebbles included. Though Mr. Carne some time since called attention to the general facts connected with the stream-tin of Cornwall as furnishing strong evidence of a sweeping inundation having passed over the land, 'the effects produced by which have never been repeated by any subsequent flood,' less attention seems to have been paid to this evidence, while the distributing causes of various superficial gravels of England have been under consideration, than the relative importance of the subject appears to demand. . . . . . . 'The peculiar situation,' observes Mr. Carne, 'in which nearly all the stream-tin of Cornwall is found, compared with the localities of the most productive tin veins, is highly illustrative of the direction in which the current of the deluge swept over the surface. . . . . Now, on looking at the direction which the stream bears from the mines, it will appear most probable that the course of the current, which swept the tin from its original situation, must have been from North to South, or rather from N.N.E. to S.S.E.'—Trans. Geol. Society of Cornwall, vol. iv. p. 110. . . . . A great mass of detritus seems to have been swept into the British Channel from the northward, and this we could scarcely suppose would happen without a great body of water passing downwards to the southwards, carrying before it, when it struck the opposite shores of the British Channel, a large proportion of the disintegrated or decomposed surfaces of rock which existed in that direction, transporting them into the chief inequalities, and carrying them down the principal valleys, according to the direction of the minor currents produced by the inequalities of the land beneath"—De la Beche, *op. cit.* p. 397, etc.

In 1851 Murchison published his famous essay on the Flint Drift of the South-east of England. In this paper he says, *inter alia*: "From Petersfield to East Bourn, where the drift becomes for the most part an accumulation of clay or loam, I have nowhere seen it exhibit signs of successive bedding; but everywhere proofs of its having been accumulated suddenly and tumultuously, whether it be lodged on the Lower Greensand or on the Weald Clay" (Journ. Geol. Soc., vol. vii. p. 355). Again, after discussing the mode of distribution of the angular drift, *occurring, as he says, at such various heights and so completely out of the reach of all rivers ancient and modern*, he concludes that it may best be explained by a drift or current acting from west to east, which merged the chalk flints with the *débris* of the harder beds of the sandstone over which it passed, and translated fragments of chert from the still lower and well-exposed inferior member of the same formation. "This view," says Murchison, "supposes that the movements which fractured the rocks along the western portion of the great anticlinal of the Weald were accompanied *by a sudden rush of waters*" (*id.* p. 357).

In explaining how it comes about that in some cases the drift gravel is not found in the valleys, but only in the eroded cavities on the higher ground, he says: "In all these facts I can only recognize the results of an agency of vast intensity, and clear proofs of a great force that drifted the flinty material in this district from west to east. . . . . We may therefore, I repeat, suppose that a current translated this *débris* and swept generally along from west to east, gathering fresh materials from the harder parts of the subsoil over which it passed, and that it traversed promiscuously low hills and dales, in this case, *i.e.* between West Grinstead and the gorge of the Arun, along the chief line of the existing drainage, but at great heights above its present level. Other facts favour the inference that a former powerful but transient current denuded the surface of the bare rocks in many parts, and at the same time distributed broken materials along a zone of limited width," etc., etc. (*id.* p. 358).

Another fact cited by Murchison is the curious way in which the flint drift is accumulated in the transverse valleys by which the rivers Arun, Adur, Ouse and Cuckmere escape from the Weald through the Chalk to the sea, and exhibits ancient mounds of drift, arranged irregularly and at different altitudes upon their banks from 20ft. to 100ft. above the present rivers. "A glance," he says, "at any of these materials at once bespeaks the tumultuary nature of their origin, for none of them contain rounded or water-worn pebbles."

At Peppering, about 80ft. above the Arun, and midway in the gorge of the chalk, bones of an Elephant were found, as stated by Dr. Mantell. In the defile of the Arun the promontories of North Stoke and South Stoke are just in such relative positions as we may suppose would have arrested or thrown off to the opposite sides masses of detritus hurled along the valley; and Peppering, being a bay opposite to the round promontory of Arundel Park, is therefore a spot where we might look for a collocation of drift with bones. The more open and straighter chalk-valleys of the Adur, with no marked promontories or masses, was little likely to arrest much drift, which has chiefly been translated to the sea-board" (*id.* p. 360).

Again, "I believe that the detritus in and around Pease Marsh was chiefly the result of disturbances of the adjacent strata, whilst broad and torrential bodies of water were moved along under the escarpment of the North Downs and translated the *débris* into natural depressions" (*id.* p. 378). Again, speaking of the angular chalk flint near Gomshall, he says, "As no streams have ever descended over these hills of sandstone, since the present configuration of the land and denudation of the country were effected, I equally refer them to the same agency of drift as that which swept greater volumes of them into the adjacent hollows" (*id.* p. 379).

Again, "Fossil bones have been found at and near Folkestone, at heights varying from 80 to 110 feet, not in different beds, but always in the same broken flint debris. They have also been detected in an upper combe or recess in the chalk escarpment nearly two miles west and by north from Folkestone, and at an altitude of not less than 222 feet above the adjacent sea. . . . With the fact before us, that these fossil bones lie at once upon the bare rock *in situ*, without any deposit between it and the drift in which they are commingled, it seems impossible to explain their collocation (even if we put their position out of the question) by supposing that they were tranquilly buried under a lake, or fell from the banks of any former stream. In those cases it would indeed have been miraculous, if ruminants and carnivores had assembled themselves at a particular moment of time to be interred, like a 'happy family,' in one thin course of detritus, and at the bottom only of the sedimentary matter! To my mind, the circumstances of the same drift being placed at such different levels at Folkestone, and of its sloping up from the seaboard to the height of 222 feet inland, are good evidences that these creatures were destroyed by violent oscillations of the land, and were swept by currents of water from their feeding grounds into the hollows in which we now find them, and where the argillaceous materials which covered them have favoured their conservation. Nothing can more strongly favour this view than the manner in which fragments of chalk-flints, often angular, are wedged together in the matrix of loam, and enter into the cavities of some of the vertebræ and broken bones of the large quadrupeds" (Journ. Geol. Soc. vol. vii. p. 386).

Lastly, after contrasting the angular flints we are discussing with the rounded flints of the Thames Valley, and urging that the rounding of the latter was an operation of the early Tertiary period, Murchison goes on to say that "from the slopes of the South Downs to the sea, where very few rounded Tertiary pebbles have ever existed *in situ*, we clearly see that after the first rush of waters, whether down the talus of the chalk or through lateral openings, the fractured flints must have been left as originally piled up, and, being desiccated, have never more been subjected to the action of water and have remained in their angular state" (*id.* p. 389). These extracts from Murchison might be greatly extended; for the very long and remarkable paper which is here quoted, and which to my mind is one of the most acute and profound ever written by the famous author of the Silurian System, is devoted to urging that the distribution of the surface deposits of South Britain requires for its explanation such a cause as we are arguing for. From the weighty opinion of Murchison we may turn to the equally weighty opinion of Mr. Prestwich.

Mr. Prestwich read a paper before the Geological Society on the 25th of June, 1851, in which the following remarkable passage occurs: "In a paper on the Brighton Drift (*i.e.* the paper just cited), Sir Roderick Murchison expressed an opinion that the accumulation of the Mammalian chalk and flint rubble *was sudden and tumultuous. In this view I quite agree*, and also conclude that the same rapid mode of accumulation is to be attributed to the Sangatte Drift. For if the action had been slow and gradual, the rolling to which the broken flints would have been subjected must inevitably have more or less blunted their edges; and further, any rounded flint pebbles from the Tertiary strata would only have been more rolled and rounded. But, on the contrary, we find in this chalk-rubble broken angular flints with edges as sharp as a knife, and with fractures as clean as though they were just broken with a hammer, while the small, hard, *round* flint pebbles from the Tertiary strata are often broken in two or more pieces, and these pieces neither rolled nor worn. Some which are entire, and likewise many of the flat broken lumps of iron-sandstone, are also found, as it were, standing on end, their longer axes perpendicular to the lower surface of the deposit. Again, with regard to the finer sediment, if the accumulation had been tranquil, this would have tended to have formed separate and distinct layers; whereas we find an almost impalpable chalk paste full of small and large angular and rolled fragments of chalk, and this chalk paste occasionally replaced by sands apparently of Tertiary origin, almost unmixed, and as though lifted up and transported bodily, and without being broken up. The whole mass is roughly stratified into certain divisions; but in each division the materials are mixed together perfectly independently of their specific gravity. Impalpable chalk silt, which the most gentle current, if maintained, would remove, is found enveloping masses of broken chalk-flints, whilst large massive flints, scarcely at all worn or broken, and requiring for their transport considerable power, are found dispersed indiscriminately in the finest sediment and in the coarse shingle. The flint-rubble is also often heaped or piled, as it were, together, giving rise to a roughly contorted appearance. Further, a deposition under the ordinary conditions of accumulation in water would have led to the probability of traces of the contemporaneous fauna occurring. It seems to me probable, that the action which led to the accumulation of this drift *was sudden, powerful, tumultuous, not of long continuance, and suddenly arrested.* At the same time I do not believe that it was of a nature to break and fracture the great mass of angular flints; but these having been in great part broken and shattered by previous disturbances, while in the body of the chalk, that they were removed, *not so much, by rolling at the bottom of the water, as by transportation in mass with the waters.* Such a force, while it would uproot and tear away large portions of the chalk and tertiaries, might, if the distance were not great, transport, comparatively unbroken, masses of the softer strata, and even the more delicate shells which they contain. The condition of the mass would depend, therefore, entirely upon the distance which it had travelled, and the nature of the ground over which the waters passed. If we suppose a large body of water to be moving with a velocity sufficient to transport large blocks, then necessarily, the smaller debris and the mud and silt would be carried along with them; but when the velocity is only sufficient to move the finer debris, then the larger blocks and coarser materials must be left behind. In the former case the heavier portions would subside first, and the lighter ones be carried to a distance and become gradually more worn. But let this current be arrested in the early part of its course, and then we shall have a deposit of mingled debris, the less sorted the nearer we approach to its point of origin, and if this should be effected after a short transport, and without meeting with any material impediments, then masses of clay and sand with their imbedded organic remains, however delicate, as well as the bones of animals occurring on the surface of the ground, may, I apprehend, be transported comparatively uninjured and unbroken. Should, however, any impediments occur to obstruct their progress, or any conflicting currents disturb the uniform and regular sweep of the moving mass, then the clash of the debris will more or less break and wear both the organic remains and the rock detritus in proportion to their hardness and power of resistance; the more friable and delicate specimens being destroyed first, and only the harder bones and rock debris holding out to the last. The whole mass would become more intermingled. In the case of the Sangatte Drift the materials do not appear to have travelled far, the lower portion of it seems to consist of pure chalk-rubble derived from the adjacent lower chalk, and the upper parts being full of flints which probably came from a more distant point of the same range of hills. The whole mass seems to have been checked and thrown down after but very little wear, and in a manner comparatively independent of the specific gravity of its component parts: whereas if the action which accumulated these materials had been slow, gradual, and long-continued, they would most likely have been sorted according to their specific gravities; and more particularly as all the fragments in any given layer would have been subjected to a force acting comparatively with equal power, and in an equal manner they would necessarily exhibit a nearly like amount of wear; varying in the different specimens according to their hardness, but the measure would be alike for all. In this, and the analogous case at Brighton, an impalpable chalk-silt would, I apprehend, be incompatible with coarse siliceous sands—worn pebbles with coarse angular flints—and entire and perfect bones with others, some of which are broken and others rolled and worn."

These are the views of the Nestor of Post-glacial Geology, Mr. Prestwich, as announced in 1851, and they are the views he maintains still. Before quoting a later opinion of his I would intercalate a passage from a published paper read in 1860 by the Rev. O. Fisher. In describing the denudation of certain parts of South Britain he has some remarks very germane to our subject. He referred to the existence of evidence of torrential action of water in several Chalk districts, for instance, "the perfect drainage system of the dry valleys of Salisbury Plain and other extensive tracts of chalk downs, the loose flints filling the bottoms of such valleys, and the immense blocks of tertiary pudding-stone and 'Druid Sandstone' scattered along the bottoms of chalk valleys, as in the Portisham and Bridehead valleys near Weymouth, and the Marlbrough 'Wethers' in Wiltshire. Mr. Fisher also thinks that he sees evidence of the friction of a great body of water rushing down a hill-side in the manner in which vertical or nearly vertical strata are usually bent over at their exposed edges."

To revert to Mr. Prestwich. In a paper on the "Phenomena of the Quaternary Period in the Isle of Portland and about Weymouth," read before the Geological Society, on June the 10th, 1874, after an elaborate examination of these surface deposits he says, "It is evident that we have in this deposit a surface wash composed of the loose *débris* of the rocks of the vicinity, of the shells and slugs of a land surface, and of the remains of animals which might have frequented the same. It seems to me that the results may be ascribed to one of three causes, either, first, a mass of ice passing over the surface of the land may have pushed forward the *débris* and thrown it seaward down valleys and over cliffs, turning over their edges; or, secondly, the accumulations of winter snow may, on sloping surfaces, have tended in a lesser degree to the same result; or, *thirdly, the transient passage of a body of water may have swept the land débris* down to the shore-line and to a certain distance beyond. With regard to the action of ice, I feel about it the difficulty before expressed on the score of the presence of organic remains, and also although a local mass of ice might have radiated from the higher central ground southward towards the Bill, and in a north-westerly direction at the other end of the island, the size of Portland and its height are too limited for local glaciers; while if it formed part of a continental ice-sheet, it would have a more definite and uniform direction, and we should expect to find on the adjacent mainland traces of that ice-sheet, which we do not. The limited size of the island forms also a similar but not so strong objection to the operation of accumulated snow. '*I find in the third alternative an explanation which agrees with the observed conditions.* Sir R. I. Murchison, with respect to the Brighton cliff, and myself with respect to the Sangatte cliff, had, so far back as 1851, arrived independently at somewhat similar conclusions regarding the conditions under which they were formed, save only that his generalizations were more extreme, attributing to one operation what I should attribute to several. He supposed that the angular debris resulting from an extended catastrophe caused by great waves produced by great oscillation and violent fractures of the crust of the earth, 'by which the earth's surface has been so powerfully affected in former times,' passing over the land, and by 'the large area under consideration being suddenly broken up and submerged.' I then limited my conclusions to the fact that the accumulation of the Sangatte drift was tumultuous and of short duration, and that it was formed under water."

A third very opportune paper for my purpose, also by Mr. Prestwich, was published by him in the May number of the Geological Journal, p. 127, etc., "On a Peculiar Bed of Angular Drift in the Lower-Chalk High Plain between Upton and Chilton." In this paper he describes a considerable deposit of angular drift containing Mammalian remains and land-shells and angular pieces of chalk. "The bones," he says, "were mostly in a broken and fragmentary state, but though broken they are not rolled or water-worn." . . . "All the fragments of flint, even the smallest (and they are few more than two or three inches in length), are perfectly sharp and angular, and are generally not discoloured." Mr. Prestwich says of the deposit: "There is no trace in any part of this section of stream or river action, . . . . the shells consist essentially of land shells; the two exceptions are so rare that they only prove the rule; for *Planorbis albus*, which lives on water plants and frequents marshes, can pass over land surfaces, while the *Limnæa truncatula* is nearly amphibious, being more frequently met with out of the water than in it; it is also found in very elevated spots."

The peculiar features of this drift are enumerated by Mr. Prestwich, as the absence of worn debris indicating prolonged water action, and of either marine or fluviatile remains; the presence, it may be said, exclusively of the remains of a land fauna; its high position of 150 to 260 feet above the adjacent river level; the irregularity of its bedding; and its wide spread, westward, towards Hendred over the adjacent plain. He identifies it with the angular drift of Sangatte and Brighton, with which it agrees in containing similar Mammalian remains, having the same irregular bedding, the same absence of wear in the component materials, and at Sangatte the same land shells. The only difference being that the drift at Sangatte and Brighton was more flinty and coarser, which is accounted for by the adjacent flint at Chilton being the Lower Chalk, and that at Brighton the Chalk with flints. This deposit of inland drift which, as Mr. Prestwich says, follows no river course, and is neither a marine drift nor a glacial drift from the northward, shows very clearly that the so-called Channel river which even the most exuberant imagination would hardly carry as far as Chilton is, apart from all the other considerations we have urged, utterly inadmissible as a postulate to explain the angular drift, whose distribution there can be little doubt, as Mr. Prestwich has so well urged, is due to a translating mass of waters which has filled the hollows and pockets in the surface of the chalk with it, and also distributed the Sarsen stones which occur at Chilton as they do further north.

The opinions here quoted are assuredly most weighty, and they more than justify the conclusion which I have arrived at independently, and which was formulated by Professor Sedgwick, an "Old Master" whom I have not previously quoted in these papers, where he says that "diluvial torrents have swept over the land, driving before them immense masses of gravel," adding, "that all the diluvial detritus originated in the same system of causes, which having produced their effects, were never repeated" (Ann. of Phil. vol. ix. p. 248).

Well may Mr. Belt remark that of late years, "the evidence that abounds of violent and tumultuous deposition has been almost ignored under the influence of the teachers of the theory of subaerial denudation." . . . "In Cornwall and in Devon," he adds, "as well as in Sussex and Surrey, independent observers, including the most illustrious of our geologists, have published their convictions that great currents of water poured across the country. I do not know what other geological conclusion has more evidence to support it" (Journ. Geol. Soc. vol. xxxii. p. 87).

This is the view I maintain most strenuously. I ventured to say in a previous paper that the geological evidence amply supports the position required by the archæological and palæontological evidence that the period of the Mammoth came to an end by a catastrophe in which a vast movement of water overwhelmed a large part of the Northern Hemisphere. In order to examine the problem methodically, I have first considered those areas which are outside the limits of ordinary glacial phenomena, and have consequently limited myself entirely to that southern zone of European deposits marked by loams and gravels, but free from boulders and glacial clays, a district generally considered to be bounded in England by the Thames valley and a line joining its upper part with the outfall of the Avon into the Severn. It is assuredly, however, *a priori* almost necessary that if such a flood of waters once passed over this more southern zone, that it must have left abundant traces far beyond these limits, and that we ought to find such traces much further north and among those beds which have been hitherto left entirely in the hands of the Glacialists. I believe that such traces do in fact exist on a very notable scale, and that it is because the postulate of a Post-Glacial catastrophe has been overlooked by those who have examined them, that much which is obscure, difficult, and contradictory about these beds refuses to yield to explanation. I will now turn to them, and the next paper will deal with the Evidence of the Marine Drift.[1]

(*To be continued.*)

## NOTICES OF MEMOIRS.

### I.—Proceedings of the Cotteswold Naturalists' Field Club, for 1881-1882.

THIS part of the Proceedings of the Cotteswold Club commences their eighth volume, and includes accounts of the thirty-sixth and thirty-seventh annual meetings. At these meetings, held (in 1881 and 1882) at Gloucester, addresses were delivered by the President, Sir William V. Guise, Bart., F.L.S., F.G.S., etc. The losses sustained by the Club, by the death of John Jones (of Gloucester), Charles Moore (of Bath), and Dr. John Lycett (formerly of Minchinhampton), were duly mentioned, and accounts were given of the various excursions to places of interest, when the geology, natural history, and archæology were duly investigated. Geology seems to have monopolized the attention of the members at their evening meetings, for the separate papers printed in this part of the Proceedings are entirely devoted to that science. Mr. Handel Cossham discourses on the Cannington Park Limestone, from which he has obtained fossils that confirm its Carboniferous age. Mr. E. Wethered gives an account of the strata exposed in a railway cutting at Morse, near Drybrook, in which he identifies an outlier of Trias, yielding quartzite pebbles like those of Budleigh Salterton. Mr. W. C. Lucy contributes a list of the minerals of Gloucestershire, and of part of the adjacent counties of Somerset and Worcestershire; and also a list of derived rocks found in the northern drift gravel over the same area. Mr. E. Witchell describes the Pisolite and the basement beds of the Inferior Oolite of the Cotteswolds. He gives an interesting account of the "Pea Grit" or Pisolite, and shows by sections some of the changes that took place in the deposits of the Oolitic sea.

Dr. Wright describes a new species of Star-fish (*Uraster spinigera*) from the Forest Marble, near Road, Wiltshire; a new species of Brittle Star (*Ophiurella nereida*) from the Coral Rag of Weymouth, and a new Astacamorphous Crustacean (*Eryma Guisei*) from the Inferior Oolite of Leckhampton Hill. H. B. W.

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[1] In the October number of the Magazine, p. 439, l. 12, *patent* ought to be *potent*.

### II.—ON THE CARBONIFEROUS LIMESTONE OF THE WESTERN SAHARA. By Dr. G. STACHE. Proceedings of the Imper. Acad., Vienna, June 22, 1882.

IN his journey from Morocco to Timbuctoo, Dr. O. Lenz collected many fossils characteristic of the Carboniferous Limestones. Four groups are distinguishable, namely—1. Productus-limestone of Fum-el-Kossan in the northern region of the West Sahara, and the calcareous zone of Wady-Draa. 2. The Spirifers in the sandstones of the middle region. 3. Corals and Crinoids at several localities along the Western Stony Desert. 4. Fossils in the marls and limestones with Crinoids at Igidi in the south part of the Carboniferous-limestone region.

These groups represent portions of a great Carboniferous-limestone fauna; and the lower unproductive subdivision of the Carboniferous system is by far the most extensive series of strata in the wide north region of depression in the Western Sahara. The Productus-limestone of the northern zone, and the Crinoidal marls with Productus of the southern zone, belong to a series corresponding with Gosselet's "Etage du Calcaire de Tournay," or the lower subdivision of the Carboniferous Limestone of Belgium. The Lower Carboniferous strata in the middle and eastern portion of the great area of depression in the North Sahara may possibly be of more importance than hitherto supposed.

It is probable that during the early part of the Carboniferous Period the sea limited the Mid-African Continent along an extensive East and West coast-line; and that during the same period there was an open communication between the North-African sea and that which was inhabited by the faunæ of the Belgian and South Alpine Carboniferous Limestones, both abounding in *Productus*.

COUNT M.

## REPORTS AND PROCEEDINGS.

### BRITISH ASSOCIATION, SOUTHAMPTON, AUGUST, 1882.

### I.—THE GEOLOGY OF CARDIGAN TOWN. By Walter Keeping, M.A., F.G.S., Keeper of the York Museum. (Read before Section C.)

A FEW years ago, in the course of a geological investigation in South Wales searching for the base-line of the Llandovery group of rocks, I came to the town of Cardigan.

Now, seeing upon the Geological Survey Map the tract of country between Cardigan, Newport, and Dinas Head, in Pembrokeshire, marked, like the Aberystwyth Grits, 'b. 4,' *i.e.* Lower Llandovery, I came here in the full expectation of finding the rocks of the same Llandovery age.

But the first glance at the cliffs in Newport Bay showed that this was most unlikely to be the case; for the grit beds here are of quite a different type from those of Aberystwyth, namely, pale blue and grey felspathic grits, much less quartzose, and very ash-like in appearance; and they weather brown and red; also the slates are of that deep black type, powdering soot black, and occasionally ribboned with paler bands, so characteristic of the older slate groups of Llandeilo and Arenig age. Some of the grit beds exhibit curious tortuous structures upon their under surfaces.

Working in the cliff south of Pen Pistill, Newport Bay, I found a few species of Graptolites, which I hoped would have decided the age of these rocks; but Mr. Lapworth, who has kindly examined them, writes that they are not sufficiently well preserved for identification, and might be either Lower Llandovery, Llandeilo, or Arenig species. The *Diplograpsus* may be new, and "seems to be a very close ally of *D. modestus* of the Lower Birkhill Shales." The other species is a *Climacograptus.*

From the lithological character alone I have no doubt that these beds are not of Lower Llandovery age, but belong to an older group: and this conclusion is borne out by our examination of the northern beds of this grit area, at Cardigan, whose stratigraphical position, in the Middle Bala, we shall prove beyond a doubt.

Here, around Cardigan Harbour, I found precisely the same kind of rocks as in Newport Bay, the grits still pale and highly felspathic, with scattered mica plates, often closely resembling an altered volcanic ash; and the slates are likewise of the same black type. In these slates, just beyond the little bridge over the stream at the S.W. end of Cardigan town, I found Graptolites which have been determined by Mr. Lapworth as *Dicellograptus Morrisii,* Hopk., and *Diplograpsus socialis,* Lapw.

Now, *Dicellograptus Morrisii* is, as Mr. Lapworth writes to me, "*most emphatically a Bala* fossil. It is unknown in the Lower Bala (Llandeilo-Glenkiln) beds of either Scotland, Ireland, or Scandinavia; but it occurs abundantly in the *D. Clingani* and *Pleurograptus linearis* zones of the Hartfell shales; that is to say, on, or not far below, the horizon of the Bala Limestone." "This also is the horizon of *D. socialis* in Scotland; *D. Morrisii* and *D. socialis* occur associated in the Middle Caradoc beds of Girvan."

There can, therefore, be no doubt that these rocks are of Bala age, and not Lower Llandovery, and it thus appears that the older slate groups of Llandeilo and Bala age extend up northwards beyond the Priscelly and Llanlawer Mountains, through Newport Bay as far as Cardigan Harbour. Here, then, we have a definite base-line whence we can work northwards, along fine cliff-sections, to the incoming of the Aberystwyth grits, which first appear seven miles off, near Castellbach, south of Llangrannog.

*North of Cardigan* the rocks are found soon to become *coarser and paler*; massive rolling beds of coarse flaggy slates, some of them arenaceous, and pale splintery slates, being seen in a number of quarries and other small exposures. Bands of "cone-in-cone" nodules and beds of rab and shale are seen S.E. of Aberporth, so that the series, in its upper part especially, comes to *resemble* the *Metalliferous slates* of Central Wales. The cliffs north of Aberporth, up to and beyond *Penbryn,* are made up of the same slaty series; namely, imperfect slates, and irregular shaly slates, of rather dark bluish colour, only varied by the occurrence, here and there, of lines of *cone-in-cone* nodules and thin bands of grit.

In all this stretch of country I find *no break* in the rock series. It is a great slate country, there being, indeed, *no grit bed* of sufficient development to serve for such local purposes as rough building or road-mending. All hard 'road metal' is obtained either from the boulders of Felsite, Greenstone, Grits, etc., scattered over the surface, or from some beds of sandstone higher up in the series, which we proceed to notice. The sandstones are well seen in quarries on the top of the cliff, some half-mile north of *Penbryn*; in a wood near Morfa Ganol; and, further east, in a road quarry at Llain. They form a *compact series of thick grit* beds, some twenty feet in all, pale-coloured and sharp-jointed. Some of the beds show a well-marked development of coarse tortuous prominences upon their under surfaces; and one bed near the centre of the series is broken up into coarse rubbish by lines of concretionary structure.

The *rock* is a finely granular sandstone crowded with fragments of felspar, and with some small black grains and crystals; colours *pale blue grey* to greenish yellow weathering to fox yellow. In the cliff quarry the rock is darker and less felspathic.

The stratigraphical position of this grit zone is in the upper part of the imperfect shaly slate series above described. It lies *conformably* in that series, and does not appear to mark out any geological break; lithologically the rock agrees very closely with the sandstones of Cardigan Harbour. Above this we again find, in Dogskin Bay, a dark imperfect slate series and dark leaden blue rab, in which concretions of grey grit begin to appear; then *thin beds of concretionary grit* gradually come in and develope, until in Fraethbach and at Llangrannog we find ourselves upon the undoubted Aberystwyth grit series, very well developed. The grits are of the regular concretionary mid-Wales type, with contorted structure and strange volutions, and other prominences upon their under surfaces, while all the associated argillaceous beds present all the forms of rab, shale, and pencil rab, such as we find at Alltwen, Aberystwyth. Still, a conspicuous difference of general character is produced by a want of the regular thicknesses and orderly alternations of the beds of grit and shale as found further North. For here, indeed, we have the gradual tailing off of the grit series as it dies away to the South. In this district the section at Fraethbach must be noticed for its wonderful developments of concretionary grit structures, which I hope to describe elsewhere. At Llangrannog the Aberystwyth grits are very well developed. They dip inland, to the east, and, a little above the church, are seen *passing conformably* under a series of imperfect *slates* and flags, with fucoidal and worm markings upon their surface. The easterly dip holds pretty steadily on towards Pigeonsford and along the hill-sides south of Llangrannog valley, where pale shaly slates and hard slate rock, belonging to our Metalliferous group, are uniformly developed.

*Resumé.*—(1) The pale felspathic grits and black slates of Newport Bay and Cardigan are of Middle Bala, or Caradoc age (not Llandovery, as hitherto supposed). Above these come (2) rolling beds of pale-coloured, coarse, flaggy slates, and pale blue splintery slates, doubtless also of Bala age. Some rather darker shaly slates (3) with rably shales, and "cone in cone" concretions, next succeed; and then we meet with (4), a small compact set of pale felspathic grits of the same character as those at Cardigan. These also I regard as probably of Bala age (Upper Bala Slate Series). The overlying rather dark shaly slates (5) with some rab, presenting the gradual incoming of the Aberystwyth Grits, are I believe passage beds of Caradoc-Llandovery age.

The Grits of Llangrannog are clearly the same as those of Aberystwyth (Aberystwyth Grits), and the overlying slates with worm-like markings are our "Metalliferous Slates," which belong to the same great rock group.

There is no evidence of any stratigraphical break in the rock groups of South Cardiganshire, from the Llandeilo to the Llandovery periods inclusive; but the whole series appears perfectly continuous. The Aberystwyth Grits are less developed than further north, this being near the line of their southerly disappearance by dying out. As in North Wales (Dovery Valley), we find here a considerable series of Upper Bala Slates passing up into the Llandovery group. I have proved elsewhere[1] that our Cardiganshire rock series occupies a position conformable beneath the Tarannon Shale, and here we have the evidence that it is superior to and conformable with the Bala formations. No exact upper boundary line for this group can be determined, for it passes up insensibly into the Tarannon Shale, and again in its lower horizons we find its limits ill defined, gradually passing down into a great series of imperfect slate rocks, the main mass of which belongs to the Upper Bala Group. We find no great physical break, but perfect continuity amongst the Silurian and Cambrian rocks of South Wales.

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## II.—On the Origin of the Hæmatite Deposits in the Carboniferous Limestone.[2] By Edward Wethered, F.G.S., etc.

MUCH has been written on the origin of iron ore deposits by Doctors Sterry Hunt[3] and Bischof,[4] both of whom insist on the active part which decaying vegetation has taken in the process. According to the former authority,[5] "we find in rock formations of very different ages, beds of sediment which have been deprived of iron by organic agencies, and near will generally be found the accumulated iron." . . . "I now wish," he says, "to insist upon the property which dead and decaying organic matter possesses of reducing to protoxide, and rendering soluble, the insoluble peroxide of iron diffused through the rocks." The chemical reactions which take place are briefly these. Iron in the state of ferric oxide comes in contact with decomposing vegetation and yields up oxygen to the carbon, a molecule of carbonic acid being formed by the combination of one atom of carbon with two of oxygen. The iron is then reduced to the ferrous state in which it is soluble in water containing carbonic acid. Another chemical change then takes place, by which the iron unites with carbonic acid and a carbonate results. When oxidation is possible the carbonate of iron becomes oxidized, and a deposit of peroxide of iron takes place. A practical instance of what I have just described was seen when down the Easton Colliery, near Bristol, a few months since. Water was issuing from some old workings, and on entering a road of the mine where fresh air was travelling, a ferruginous deposit took place. Again, I once had occasion to descend an old shaft of a coal-mine which had not been worked for many years; near the bottom of the shaft, water was issuing from the old workings, and there was a deposit of peroxide of iron about half an inch deep. On penetrating further into the workings where the atmosphere had been, until recently, strongly diluted with carbonic acid, there was an entire absence of such a deposit.

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[1] See Quart. Journ. Geol. Soc. 1881, p. 141.

[2] Read before Section C. August, 1882.

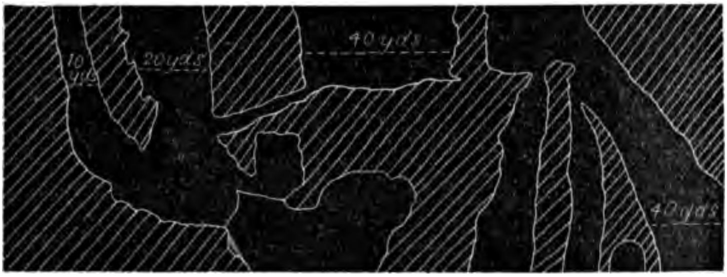
[3] Chemical and Geological Essays.

[4] Chemical and Physical Geology.

[5] Chemical and Geological Essays, p. 228.

Mr. Etheridge has extensively referred to the hæmatite deposits in the Carboniferous rocks of the West of England,[1] and mentions the occurrence of ore "nearly everywhere" where the Magnesian Conglomerate rests upon the Carboniferous Limestone, and a section is given which admirably shows the hollows or "pockets" in which it is found. The deposits, however, which occur in the limestone are differently situated compared with those which rest upon the top, to which the term "pocket" is appropriately applied. The following is a section of a portion of the Carth Mine near Cardiff, which shows the position in which the hæmatite occurs.

Section showing mode of Occurrence of Hæmatite in the Carboniferous Limestone.



Carth Mine near Cardiff.

While visiting this mine, I was much struck with the resemblance of worked-out so-called "pockets" to natural caverns. Of course any excavation in the rock becomes a cavern, but the pockets are natural caverns; all the miner does is to work out the ore. I also took occasion to ascertain what were the signs which indicated the approach to ore, and I was informed that they were as follows:—

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[1] Proceedings of the Cotteswold Club, 1865, p. 47. Also Quart. Journal of Geol. Society, 1870, p. 183, from which quotation is taken.

1. Joints appear in the limestone through which water percolates.
2. An ordinary cavern appears, termed by the Welsh miners a "Locus," the sides of which are often covered by crystalline and crystallized carbonate of lime.
3. Traces of ore appear in the "Locus."

The fact that the first indications of ore are cracks in the rock down which water percolates certainly points to the inference, that it was by a like percolation that the hæmatite has been brought into its present position.

The next point for consideration is: from whence was the iron derived. The highly ferruginous condition of the Carboniferous strata is well understood, and the fire-clays[1] indicate that large quantities of iron have been reduced to the soluble state and removed by water. But as to whether it is this iron which has been deposited in the limestone is a matter for consideration. It is questionable whether sufficient time could have elapsed for the formation of the caves to admit of the supposition that the iron had been derived from these rocks prior to denudation by the Trias sea. We must, however, remember, that the denudation extended over a great lapse of time, during which much of the limestone now not covered by the Coal-measures or Millstone-grit was overlain by these formations.

Mr. Etheridge considers the Carboniferous hæmatite deposits in the West of England to have arisen from the infilling of faults, fissures, etc., during the denudation by the Trias sea. Referring to the hæmatite deposits which occur in the Pennant grit, near Bristol, Mr. Etheridge says,[2] "From careful observation and examination, both in this area and others in the district, I have no hesitation in referring the origin of these extensive lode accumulations or deposits of hydrated peroxide, or brown hæmatite iron ores, to the age of the New Red Sandstone; that is to say, the fissures, faults, etc., which occurred in the older rocks (prior to the deposition of the New Red) were filled up, during the period of the accumulation of the Trias group of rocks, either through chemical changes or mechanical suspension or infiltration." Again, Mr. Etheridge says,[3] "I believe, then, that it was during the progress of the denudation of the Palæozoic rocks by the sea of the Triassic epoch that the pre-existing faults and fissures or open joints, etc., along the coast-line were mechanically and chemically filled in. . . . . Doubtless the percolation of water through overlying strata highly charged with oxides of iron, as is the case with the New Red Series, has also been a source and mode of accumulation." Though I am disposed to consider it possible that some of the iron was derived from the

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[1] Chemical and Geological Essays, p. 13.

[2] Proc. Cotteswold Club, 1865, p. 37.

[3] Quart. Journ. Geol. Society, pp. 185 to 187.

Coal-measures and Millstone-grit, by the percolation of water through the strata, yet I doubt not that the main portion was derived from the Trias. I do not, however, agree with Mr. Etheridge that the infilling took place "during the progress of the denudation of the Palæozoic rock," but that it was occasioned by percolation of water through the Triassic strata after consolidation. This water on arriving at the Carboniferous Limestone would flow down the fissures and joints wherever these occurred; but where the strata was not fissured, a comparatively small volume would filter through the actual rock—on account of its being but slightly porous. According to observations which I have recently made on the porosity of rocks, I find that a cubic foot of Carboniferous Limestone is capable of absorbing 0·043 of a gallon of water, or 3½ million gallons to a square mile 3 feet thick. I take it, then, that it is owing to this fact that we generally find hæmatite where the Magnesian Conglomerate rests upon the Carboniferous Limestone. It is much the same with the Millstone-grit of the Bristol Coal-field. A cubic foot of this rock absorbs 0·081 gallon of water, or 6 million gallons to a square mile 3 feet thick. In South Wales, however, the same formation becomes more porous, and is capable of absorbing 0·290 gallons to a cubic foot of rock, or 23 million gallons to a square mile 3 feet thick. In the Forest of Dean the grit absorbs 0·854 of a gallon of water to a cubic foot, equal to 71 million gallons to a square mile 3 feet thick. Now, it is worthy of remark, that there are no workable deposits of hæmatite in the Carboniferous Limestone around Bristol, where the Millstone-grit is very impervious to water, but they are extensive in South Wales and in the Forest of Dean, where it is more pervious to water.

To sum up my conclusions on the subject of this paper, I regard the so-called pockets of hæmatite in the interior of the Limestone as caverns into which water has percolated charged with the carbonates of lime and iron. On the excess of carbonic acid being given off, and on complete saturation taking place, carbonate of lime first separated in the crystalline and crystallized state; and subsequently, when oxidation was possible, peroxide of iron was thrown down.

As to the source from which the iron was derived, I think it possible that some portion may have come from the Coal-measures and Millstone-grit prior to denudation by the Triassic sea, but that the greater portion was derived from the Trias rocks by the percolation of water containing carbonic acid. I may just add that I am informed that in the Carth Mine the deep ore is of a superior quality to that met with higher up, and that it resembles more the Spanish mineral.

In conclusion, I beg to return my thanks to Mr. Monks, jun., of the Easton Collieries near Bristol, to Messrs. Watkins and Howell, managers of the Carth Mine, and to Mr. Henry Jefferis, of Pentyrch, near Cardiff, for permission to visit the mine.

# CORRESPONDENCE.

## ON THE DEPRESSION OF ICE-LOADED LANDS.

**Sir,—To any one who believes in a yielding condition of the earth's crust, the depression of a tract of country upon its being loaded with any adventitious accumulation of matter appears an inevitable consequence. But I prefer to argue that the depression, which seems invariably to occur under such circumstances, shows that the crust, irregular though its surface be, nevertheless has a form appropriate to its equilibrium, and that there must be a plastic, if not a liquid, substratum to allow of the observed changes of level, when the load is freshly distributed.**

**So obvious is the connexion of these conditions, that it must occur to every one who has had his attention drawn that way, that any region when loaded with ice must sink. But since the question of priority in making this suggestion has been raised by Mr. Gardner, I would point out that, as long ago as in 1865, Mr. Jamieson wrote as follows: "It has occurred to me that the enormous weight of ice thrown upon the land may have had something to do with this depression. Agassiz considers the ice to have been a mile thick in some parts of America; and everything points to a great thickness in Scandinavia and North Britain. We don't know what is the state of the matter on which the solid crust of the earth reposes. If it is in a state of fusion, a depression might take place from a cause of this kind, and then the melting of the ice would account for the rising of the land, which seems to have followed upon the** decrease of the glaciers."[1]

I have discussed this and kindred phenomena in my Physics of the Earth's Crust; and have there shown that, if the crust yielded freely to the added weight, using certain probable assumed densities for the crust and substratum, it would require a thickness of 2310 feet of ice to depress the land, so that on its emergence the old shore-line should be found at an altitude of 700 feet, at which height raised shell-beds occur in Scandinavia.

The subject of mountain attraction, referred to by Mr. Jamieson, in the October number of this Magazine, is also discussed in chap. xi. of my book.

With respect to the yielding of the crust, I think we cannot but lament, that mathematical physicists seem to ignore the phenomena upon which our science founds its conclusions, and, instead of seeking for an admissible hypothesis, the outcome of which, when submitted to calculation, might agree with the facts of geology, they assume one which is suited to the exigencies of some powerful method of analysis, and having obtained their result, on the strength of it bid bewildered geologists to disbelieve the evidence of their senses. Such appears to most of us the conclusion, that the earth is excessively rigid from its centre to its surface. For we know that down to quite a recent period it has yielded freely to pressure.

*5th Oct.* 1882. O. Fisher.

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[1] Journal of Geological Society, August, 1865, p. 178.

## ANGLESEY GEOLOGY.—REPLY TO DR. R. D. ROBERTS.

Sir,—I have just seen, after a prolonged absence from home, Dr. Roberts' paper in your August Number.

I do not know whether it is usually considered fair play to ignore the memoir in which an author has expressed his views with technical accuracy, and to base destructive criticism upon a subsequent paper, written in semi-popular language, in which the topic of the memoir is introduced simply by way of illustration. In an elaborate paper, embodying the results of the work of several years, which was printed in the Journal of the Geological Society (May, 1881), I most emphatically insisted that the altered rocks of Northern Anglesey were on the whole *not* metamorphic, but *hypo*metamorphic. Surely Dr. Roberts must have seen this memoir. If he had not, he was not qualified to express an opinion upon my views; if he had, he was not justified in misrepresenting them.

My papers on "How to work in the Archæan Rocks," which appeared in this Magazine, were written for students rather than for teachers, and the terms employed were sometimes used in a general, rather than a strictly technical, sense. Thus I avoided the term "hypometamorphic" as a refinement unnecessary for my purpose; and spoke of "metamorphic" as generally equivalent to "altered." A critic should have selected the scientific, not the popular, exposition of his author's views.

Archæan geologists will eagerly look for the evidence upon which Dr. Roberts affirms that a "passage" occurs between the black shales and the "altered Cambrian," my Pebidian, of Northern Anglesey. I have hammered over almost every patch of "metamorphic" rock in Great Britain, and have seen something of the older formations in Ireland and North America. I have studied hundreds of sections where eminent authorities had declared that a "passage" existed between unaltered strata and areas of regional metamorphism; but I cannot recall a single instance in which I was not able to resolve the "passage" into a faulted junction, or something equally inconsistent. In Northern Anglesey, the Pebidian is sometimes, especially near its junction on the south with the black shales, more highly altered than usual, and in places is truly metamorphic (chlorite-schist); so that proof of a true passage would be of great theoretical importance. When Dr. Roberts publishes this discovery, I trust he will furnish such evidence, microscopic and stratigraphical, as will remove the doubt which must necessarily attach to the mere statement that a passage exists.

Dr. Roberts does not think that the occurrence of included fragments of the "gnarled series" (which?) in the Cambrian would place him in a dilemma. In my simplicity, I thought that if B contained pebbles derived from A, A must be the older group. Dr. Roberts, however, has certain "hypotheses" on hand to help him out of his dilemma, though he candidly admits that they are not yet "working." I should think not. C. Callaway.

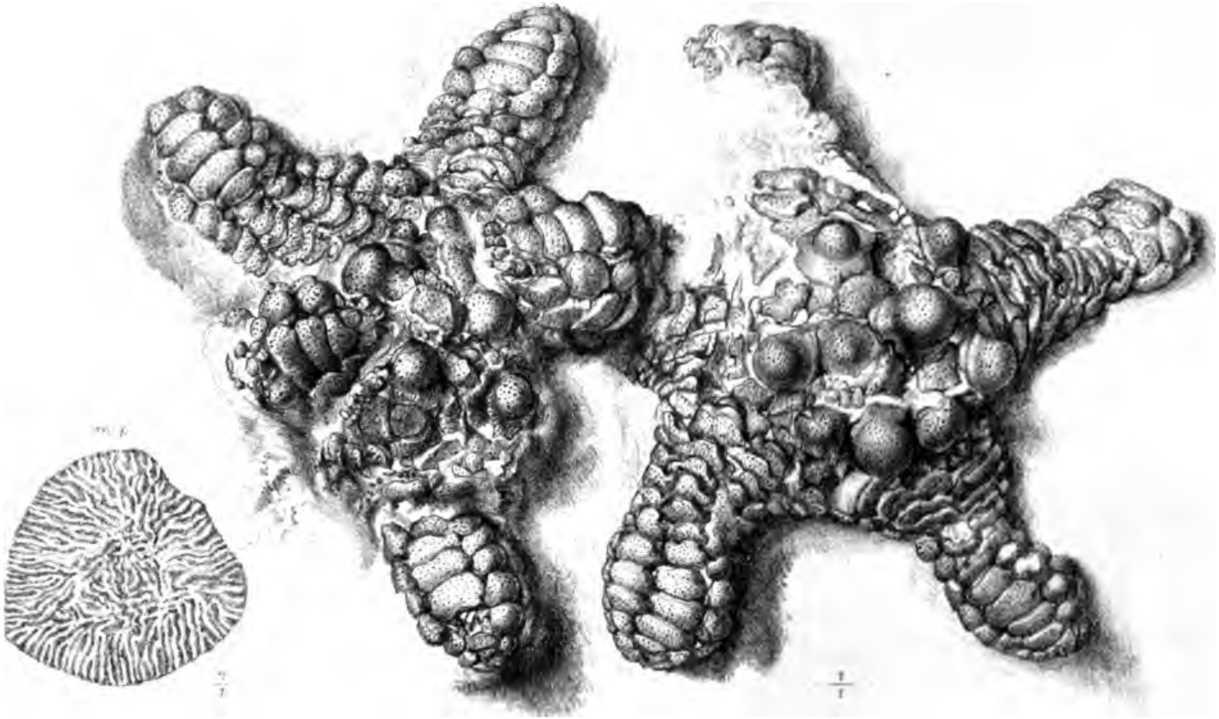
Wellington, Salop,
*September* 23, 1882.

## THE CARBONIFEROUS AND JURASSIC SYSTEMS OF EUROPE.

Sir,—The valuable paper by Mr. Twelvetrees in the Geol. Mag. for September must be welcomed by all who are interested in the attempts which some of us are making to determine the true relations of the groups of strata which occur in the European area between the Carboniferous and the Jurassic Systems. Its special value arises from the fact that it embodies the observations of a gentleman who has had opportunities, such as are offered to very few geologists of our country, for making a direct acquaintance with the important and extensive area to which the paper refers. No one can have felt more than myself the uncertainty (not to say tentativeness) of any judgment which can be formed at second-hand from the lengthy and often vague description given by the great master Murchison, whose great work still remains for western geologists the chief source of information available with reference to the Russian area. Mr. Twelvetrees' observations go further, I think, than anything which has as yet been published in this country, to throw light upon several points about which many of us must have felt much uncertainty; and for my part I hasten to take this opportunity of thanking him (as well as for his courtesy in allowing me to read his MS. before it appeared in print) for setting me right upon the matter of the recurrence of the limestone deposits in the Russian 'Permian' Series. I may also perhaps be allowed to point out the important bearing of his paper as seeming to justify a preference for regarding the German Dyas as the type of the European rocks of the age in question rather than the Russian Series; a preference which I have already expressed in my recent paper on the "Classification of the European Rocks known as Dyas and Trias." I will only now direct attention to the importance of the series of Sandstones, Marls, etc., which occur in the Orenburg country above the Magnesian Limestone formation, which, by the way, appears to be much more completely differentiated in that district than in the strictly 'Permian' region further to the north. The resemblance in many respects, though there cannot be said to be identity, between these and the 'Lower Bunter' of many parts of Germany (which are, it should be remembered, stratigraphically conformable with the underlying Zechstein Formation in Germany as well as in Russia), is of great importance. It would be premature at the present to attempt to say what is their definite position in the whole series; but facts so far seem strongly to suggest the inference that they are in sort a transition series between the Dyas and the Trias, and this conclusion is borne out by more recent results obtained by Alpine geologists.

I ought not to conclude this without acknowledging the kindness and courtesy of M. Marcou, whose many years' work on these systems ought to receive more attention than it has done from English geologists; in particular, reference may be made to papers by that gentleman (1) in the Bulletin de la Société géologique de France, 2nd Série, t. xxiii.; (2) *Ibid*, t. xxvi.; (3) *Ibid*, t. xxiv.

Wellingto[illegible] Wokingham, A. Irving.



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West, Newman & Co. imp.

Oreaster bulbiferus E. Forbes, 1850
Upper Chalk Bromley, Kent.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE II. VOL. IX.

No. XII.—DECEMBER, 1882.

## ORIGINAL ARTICLES.

### I.—Notes on *Oreaster bulbiferus*, Forbes, from the Upper Chalk, Bromley, Kent.

By P. Herbert Carpenter, M.A.

(PLATE XII.)

THE two Star-fishes represented in our Plate form part of a group of six specimens found associated together in the same mass of Chalk at Bromley, Kent, by the late well-known collector, Jeremiah Simmons, of whose persevering and successful labours in obtaining fossils from the Chalk formation abundant evidence may be seen in the beautiful series of Echinodermata in the cases of the British Museum of Natural History, some of which formed a part of the Dixon and Bowerbank Collections. He also collected for the Marquis of Northampton, and a fine Collection of Chalk Fossils made by Simmons is now preserved in the Woodwardian Museum at Cambridge.

Seven species of Chalk Star-fishes, viz. six from the Upper Chalk of Kent, Sussex, and Wiltshire, and one from the Lower Chalk of Sussex and Kent, are referred by Forbes to the genus *Oreaster* of Müller and Troschel. Most of these were only known to him by very imperfect specimens: it seems, therefore, desirable to refigure any which may have since been obtained in a more perfect state.

The following list, taken from Morris's Catalogue, gives the genera and species hitherto figured and described from the English Chalk and Greensand:—

I. Arthraster, Forbes, 1850.
  1. *Dixoni*, Forbes, Mem. Geol. Surv, Decade 2, p. 467; Dixon, Fossils Sussex, p. 336, t. 23, fig. 1. U. Chalk, Kent; Sussex.

II. Goniaster, Agassiz, 1834.
  Subgenera, (A.) *Astrogonium*, Müller.
  (B.) *Goniodiscus*, Müller.
  (C.) *Stellaster*, Müller.

(A.) *Astrogonium* 1. *angustatus*, Forbes, M.G.S. 2, p. 474; Dixon, Foss. Sussex, 335, t. 23, f. 10. U. Chalk, Kent; Sussex.
  2. ———— *Coombii*, Forbes, M.G.S. 2, p. 474; Dixon, Foss. Sussex, 334, t. 23, f. 6. L. Chalk, Amberley, Sussex.
  3. ———— *latus*, Forbes, M.G.S. 2, p. 474; Dixon, Foss. Sussex, 333, t. 23, f. 4, 5, L. Chalk, Amberley, Sussex.
  4. ———— *lunatus*, Woodward, sp.; Forbes, M.G.S. 2, p. 474; Dixon, Foss. Sussex, t. 23, f. 7; *Asterias*, Woodw. Geol. Norf. t. 5, f. 1. U. Chalk, Norfolk; Kent; Sussex; Wiltshire.

5. *Astrogonium mosaicum*, Forbes, M.G.S. 2, p. 475; Dixon, Foss. Sussex, 334, t. 24, f. 26. Chalk Marl, Dover, Kent; Sussex.
6. ——— *Smithiæ*, Forbes, M.G.S. 2, p. 474; Dixon, Foss. Sussex, 334, t. 22, f. 1, 2. L. Chalk, Burnham, Kent; Sussex.
(B.) *Goniodiscus* 1. *Bowerbankii*, Forbes; Dixon, Foss. Sussex, t. 22, f. 4. U. Chalk, Kent.
2. ——— *compactus*, Forbes; Dixon, Foss. Sussex, t. 22, f. 3. U. Chalk, Haughton, Sussex.
3. ——— *Hunteri*, Forbes, M.G.S. 2, p. 471; Dixon, Foss. Sussex, t. 21, f. 1. *G. regularis*, Mant. Med. I. p. 335. U. Chalk, Sussex; Kent.
4. ——— *Mantelli*, Forbes, M.G.S. 2, p. 472; Dixon, Foss. Sussex, t. 23, f. 11, 12. *G. semilunatus*, Mant. Med. I. p. 388. *Asterias*, Park. Org. Remains, 3, t. i. f. 1. U. Chalk, Kent; Sussex.
5. ——— *Parkinsoni*, Forbes, M.G.S. 2, p. 472; Dixon, Foss. Sussex, t. 21, f. 10, 11, t. 22, f. 4, 5, 7; *Ast. regularis*, Park. Org. Rem. 3, t. i. f. 3. U. Chalk, Gravesend, Kent; L. Chalk, Sussex, etc.
6. ——— *rectilineus*, M'Coy, Ann. Nat. Hist. 1848, p. 408. U. Chalk, Norwich.
7. ——— *rugatus*, Forbes, M.G.S. 2, p. 471; Dixon, Foss. Sussex, 330, t. 21, f. 2. U. Chalk, Kent; Sussex; Wilts.
8. ——— *sublunatus*, Forbes, M.G.S. 2, p. 471. U. Chalk, Kent; Sussex.
9. ——— *uncatus*, Forbes, M.G.S. 2, p. 472; Dixon, Foss. Sussex, 331, t. 21. f. 4, 5. U. Chalk, Wiltshire.
(C.) *Stellaster* (= *Comptonia*, *Hosia*, Gray).
1. ——— *Comptoni*, Forbes, M.G.S. 2, p. 476; Dixon, Foss. Sussex, 335, t. 22, f. 8. Greensand, Blackdown.
2. ——— *elegans*, Gray, sp.; Forbes, M.G.S. 2, p. 476; Dixon, Foss. Sussex, t. 22, f. 9. *Comptonia*, Gray, Ann. Nat. Hist. 1840, p. 278. Greensand, Blackdown, Devon; Folkestone, Kent.
III. OREASTER, Müller, 1840.
1. ——— *Boysii*, Forbes, M.G.S. 2, p. 468; Dixon, Foss. Sussex, t. 21, f. 6. U. Chalk, Woolwich, Kent.
2. ——— *bulbiferus*, Forbes, M.G.S. 2, p. 468; Dixon, Foss. Sussex, p. 328, t. 24, f. 7. (See Plate XII) U. Chalk, Bromley; Northfleet, Kent; Sussex.
3. ——— *coronatus*, Forbes, M.G.S. 2, p. 467; Dixon, Foss. Sussex, t. 21, f. 7. L. Chalk, Washington, Sussex; Burham, Kent.
4. ——— *obtusus*, Forbes, M.G.S. 2, p. 468; Dixon, Foss. Sussex, 330, t. 21, f. 12. U. Chalk, Lancing, Sussex.
5. ——— *ocellatus*, Forbes, M.G.S. 2, p. 468; Dixon, Foss. Sussex, 329, t. 21, f. 13. U. Chalk, Kent; Sussex.
6. ——— *pistilliferus*, Forbes; Dixon, Foss. Sussex, t. 21, f. 15. U. Chalk, Kent; Wiltshire.
7. ——— *squamatus*, Forbes, M.G.S. 2, p. 468; Dixon, Foss. Sussex, 328, t. 23, f. 7. U. Chalk, Kent.
IV. OPHIURA, Lam. 1816.
1. ——— *serrata*, Roemer, Kreide, t. 6, f. 23; Reuss, Kreide, t. 1, f. 26. U. Chalk, Norfolk; Gravesend, Charing, Kent.

Forbes's remarks on *Oreaster* are as follows:

Genus OREASTER, Müller and Troschel.

"Very convex, more or less stellato-pentagonal Star-fishes, having strongly constructed skeletons, often bearing on the disk large tubercles or spines. Two rows of large plates form the borders.

"This genus is synonymous with *Pentaceros* of Linck (but that ame is objectionable, since it has been applied to a genus of Fishes y Cuvier and Valenciennes). It formed part of *Goniaster* as defined y Agassiz. The fossil species are found in the Upper and Lower 'halk; and some of them bear considerable affinity to existing forms. 'hose now living are all tropical, and often of great size."

Müller and Troschel proposed the genus *Oreaster* as a substitute ›r *Pentaceros*, Linck, on the grounds mentioned by Forbes. Before ıeir time, however, the late Dr. Gray had transformed Linck's ame into that of a family *Pentacerotidæ*, in which he included such ery dissimilar forms as *Echinaster*, *Ophidiaster*, and *Pentaceros*. ıccording to Prof. Edm. Perrier,[1] it is therefore necessary to subivide this into three small families; but though retaining Linck's eneric name, he prefers to give the name *Goniasteridæ* to the last f these, in which he places *Pentaceros*, because the fourteen genera hich he includes in it are very nearly those that were formerly omprised in the genus *Goniaster*, Agassiz. Prof. Claus,[2] however, roups these fourteen genera into three more families, and names ne of them *Oreasteridæ*, though using Linck's generic name. This s considerably older than the time of Cuvier and Valenciennes, and herefore should have the right of priority; while the fish-genus of he same name proposed by these naturalists seems to have fallen ut of use, as it is not to be found in the index to Claus's Grundzüge.

Mr. A. Agassiz,[3] writing in 1877, employed *Pentaceros* rather than *)reaster*, as does Prof. Zittel in his well-known "Handbuch der 'alaeontologie" (page 427); though Dr. Lütken, of Copenhagen, ho has such an extensive acquaintance both with Echinoderms nd with Fishes, has recently revived *Oreaster* again.[4] It seems robable, however, that Linck's claims will prevail, and that the enus will be known in this country as *Pentaceros*, just as it is in 'rance, Germany, and America. The subject will doubtless be ılly considered by the accomplished naturalist who is working out he Star-fishes collected by the "Challenger"; and till his report ppears, at any rate, palæontologists may continue to employ 'orbes's nomenclature. He gave the following description of the pecies represented in our Plate.

### *Oreaster bulbiferus*, E. Forbes. Plate XII.

E. Forbes in Dixon's Geology of Sussex, 1st edition, 1850, p. 328, pl. xxiv. fig. 27; 2nd edition, 1878, p. 363, pl. xxiv. [27] (fig. 7 in error) fig. 27 on plate. Mem. Geol. Surv. vol. ii. p. 468.

"Disk very convex, covered in the centre with flat, many-lobed, unctated plates, some of which are very large. Opposite the rigin of each ray is a large tubercular, very convex conic plate, ith a wide and lobed base. The surface of all these plates is punctate; a few similar plates, but less, and more regular in form, run down the original arms. They gradually decrease and separate the origins of two series of transversely oblong, over-lapping, lined bordered, and centrally punctated plates, which alternate at the sides with a smaller row; and these are succeeded by smaller ones.

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[1] Révision des Stellérides, Paris, 1875, pp. 16–17.

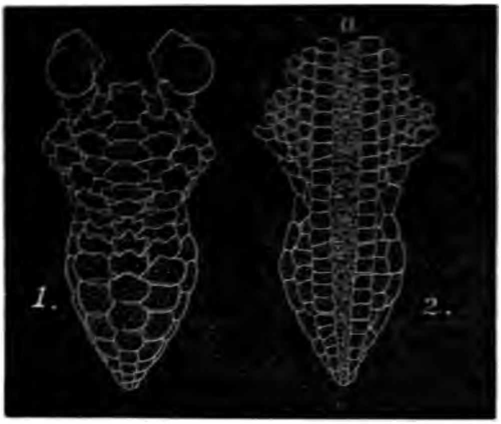
[2] Grundzüge der Zoologie, 1880, p. 342.

[3] North America Star-fishes, Cambridge, U.S. 1877, p. 108.

[4] Dyreriget. (The Animal Kingdom). Textbook of Zoology, No. 1, Copenhagen, 882, p. 613.

"The extremity of each ray is swollen into a pyriform shape, forming an eye-protecting apparatus. The summit of this is formed by very large, convex, subglobose, punctated plates, which correspond to those at the origin of the ray. These alternate at the sides with five very large, nearly flat, oblong, similarly ornamented plates, which articulate with others half their size, corresponding to the inferior row; beneath them are others much smaller, which (with minute ossicles) border the avenue, corresponding to the under row. All the plates of the bulbous terminations of the arms are much larger than those to which they correspond, except the last."

The subjoined woodcut will serve to show (1) the upper and (2) under side of an arm of *Oreaster bulbiferus*, Forbes:—



Arm of *Oreaster bulbiferus*, Forbes, 1 Upper, 2 Under side. (*a*) *ambulacra*.

"This is one of the handsomest and most curious of all the fossil Star-fishes. It is rather rare, and seldom seen perfect. One or two living species of *Oreaster* have a similar, but not equal, development of plates at the extremities of the rays." The specimen figured by Professor Forbes in Dixon's Geology of Sussex is from Northfleet, Kent; another specimen has been obtained from Sussex. The pair figured in our Plate were obtained from the Upper Chalk of Bromley, Kent, and are preserved in the British Museum of Natural History. They show the large tubercles of the dorsal surface very clearly, and in one of them the madreporic plate (*m. p.*) is also visible. The peculiar shape of the rays is well shown in the accompanying diagrams of their upper and under sides. The latter may be advantageously compared with a figure given by Mr. Agassiz of the same parts in the recent *Pentaceros reticulatus* of the North American coasts.[1]

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[1] *Loc. cit.* pl. xvi. fig. 4.

At the base of the ray the lower of its two rows of marginal plates is separated from the adambulacral plates bordering the arm groove, by the pavement-like intermediary plates of the actinal surface. In the fresh specimens these are covered by a coarse granulation which sometimes almost takes on the character of spines. They are arranged in tolerably regular rows at the bases of the rays of *Oreaster bulbiferus*; but at the point where each ray narrows there is only one row of small intermediary plates left on each side between the marginal and the adambulacral plates. Farther out, where the ray swells again, the intermediary plates increase in size, though they are limited to one row, which comes to an end a short distance from the extremity of the ray.

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## II.—NOTES ON THE SUDDEN DESTRUCTION OF MARINE ANIMALS.

### By PROF. T. RUPERT JONES, F.R.S., F.G.S., ETC.

IN the GEOLOGICAL MAGAZINE, Vol. II. 1865, p. 141, is the following interesting note on this subject:—

"Having often been puzzled to comprehend the manner in which, in some instances, large numbers of marine animals, such as Cuttle-fishes, Crabs, Lobsters, and even Fish and Reptiles, have in past ages suddenly perished in their own element and been entombed, probably on or near the *very spots* where they had been hatched out, and which they had frequented all their lives, it has occurred to me that any suggestion as to causes now in operation which might have produced then, as now, the same result, will not be unwelcome to the geological student. In the 'Principles of Geology' (7th edit. 1847) Sir C. Lyell mentions (p. 743), among other causes, the shifting of currents which might result in the carrying away of banks of sand and mud, habitats of vast colonies of cockles and other molluscs; and the effect of a storm in tearing up and casting ashore from their more solid bed great heaps of the edible oyster in the estuary of the Firth of Forth in 1831, and numbers of living whelks.

"At Stornoway, in the Island of Lewis, the largest of the Hebrides, is a depôt for Fishermen, from whence large quantities of Lobsters are every week despatched by steam-packet to Glasgow (a distance of 250 miles). These crustaceous delicacies are not packed until the latest moment, being required to reach London 'strong alive.' During the week the daily 'catches' are placed in large wooden boxes (perforated on every side so as to allow a free current of water to pass through them), and sunk in the sea at the end of the pier within the bay. On one occasion, when more than 1,000 lobsters had been so boxed up, a heavy fall of rain during the night brought down so much fresh water that in the morning every lobster was found dead, and the whole were sold, at a heavy loss, within the island.

"My friend Mr. Day, of Charmouth, informs me that after the sudden thaw at the end of January and the beginning of February (1865) such large floods of snow-water flowed into the sea along the Dorsetshire coast that immense numbers of the 'Poulpe' (*Octopus vulgaris*) have been killed and washed ashore at Charmouth. Is it not probable that these sudden influxes of fresh water—especially when at a much lower temperature, and charged with sediment—may have produced similar results in past times, as now, and may to a great extent explain the occurrence of marine organisms in a very abundant and unusually perfect state?—H. W.

"*Note.*—Sir W. Denison has remarked (Geol. Soc. Journ. vol. xviii. p. 453) that the great rains of the S.W. Monsoon periodically destroy millions of fish and other marine creatures off the coast of India. Severe frosts during low tides are highly destructive to the Littoral zone of sea-life, as noticed by Hugh Miller and others; and volcanic emanations also destroy animals and plants far and wide in both deep and shallow seas.—Edit. Geol. Mag."

Under the same heading I have from time to time collected several memoranda relating more particularly to Fishes, and herewith offer them to present notice, not that they form a complete series of such observations, but only as being suggestive, and perhaps useful to some one desirous of fully carrying out the subject.

I. Fish are killed in very large quantities by either unusual or periodical influx of fresh water from the land.

1. *On the Death of Fishes during the Monsoon off the Coast of India.* By Sir William Denison, Governor of Madras. *Quart. Journ. Geol. Soc.* vol. xviii. p. 453; 1862.

"On steaming between Mangalore and Cananore, on the west coast of the Peninsula, I was sensible of a very offensive smell, which at last I found to proceed from the sea itself. When I landed at Cananore, I found that the sea-breeze brought in a similar smell—a little modified in intensity of course; and, on inquiry, I found that for some time after the S.W. Monsoon the sea was always very offensive,—that thousands of Fish were thrown up on the shore dead. The cause of this was attributed to the mass of fresh water poured into the sea during the Monsoon. In three months, 120 inches of rain, on an average, fall upon an area of, say, 60 miles in width, for the whole length of the coast-line, from each running mile of this coast; therefore there will be about 800,000,000 of gallons poured into the sea daily; but, as most of this will come out of the rivers, of course at certain points the quantity will be multiplied twofold. The natural consequence will be the destruction of all animal and vegetable life, which, being adapted for salt water, must die after a time in fresh water. There will therefore be layers of Shells covered by strata of sand and mud, Seaweeds in various stages of decomposition, and Fish, small and great, deposited at the bottom of these seas. I saw thousands of dead fish floating; and there were, no doubt, thousands lying dead at the bottom."

2. In August, 1872, an influx of fresh water into the sea all along the southern shore of Tobago, coming from the great South-American rivers (150 miles from the mouth of the Orinoco and 900 from that of the Amazon), killed the Starfishes and other marine animals (*Nature*, December 19th, 1872, p. 124).

3. Nordenskiold noticed the fact of fresh water from the mouth of the Yenisi killing deep-sea fish.

4. Lyell has referred to the mud-floods of the Shebenacadie River, such as may be regarded as analogous to those that killed and buried the Saurians and Cephalopods in the Liassic sea.

*Vice versâ*, the fishes of the Jordan, brought down by periodical floods, are killed by the saltness of the Dead Sea.

II. Volcanic agency is very destructive to Aquatic Life.

1. The Lake Myvatn (Iceland), 20 miles in circumference, was invaded by lava, which kept the water boiling for 20 days in 1783 (*Somerville's Physical Geography*, p. 791).

2. Great quantities of fish were destroyed by lava coming down from Kilauea (*Reclus' La Terre*, Eng. ed. vol. i. p. 539).

3. Fishes were seen "cooked and floating" . . . . together "with Shellfish and other aquatic animals," on Lake Ilopango, near San Salvador, owing to an eruption of the volcano in the lake in 1880 (*Nature*, June 10th, 1880, No. 554, p. 124).

4. Lyell also refers to the dead fishes around Graham's Island in the Mediterranean; and the analogy of the surrounding deposits to the Palæozoic ash-beds has been pointed out.

III. Earthquake-waves are noticeable in this connection.

1. *On a quantity of Crabs thrown up on the Beach in Payta Bay.* By Dr. C. Forbes, R.N.—For some time previous to the occurrence of a severe earthquake-shock, on or about the 30th August, 1857, the Bay of Payta swarmed with Crabs of a kind not generally observed, and ten days after the earthquake they were thrown up on the beach, in a raised wall-like line, 3 to 4 feet wide, and to the height of about 3 feet, along the whole extent of the bay, and above high-water mark. At the same time as the upheaval of the Crabs took place, the water of the bay became changed, from a clear blue, to a dirty blackish-green colour, much resembling that off the Island of Chiloe, Concepcion, and the southern parts of Chili. Ten days afterwards, Dr. C. Forbes found that living specimens of the Crabs were still numerous in the bay, but all appeared to be sickly, and numbers came ashore to die. There were no appearances of any alteration of the relative position of sea and land in the vicinity, nor had any ebullition of gases been observed; although probably to both these causes combined the phenomenon described was due (*Quart. Journ. Geol. Soc.* vol. xiv. p. 294; 1858).

2. "*Lake Ontario Troubled.*—An extraordinary rise and fall of the water in Lake Ontario was observed for several hours on the afternoon of the 13th of June. The ebb and flow occurred every 20 minutes; that is, for ten minutes the water would gradually recede, then commence rising and continue to rise for about ten minutes. The water rose two feet and three or four inches above the ordinary level, then receded about the same distance below the usual level, making a variation in the height of the water of nearly or quite four feet and a half every 20 minutes. The water flowed up the beach some five rods beyond the point touched in still water, and it flowed back ten rods beyond the ordinary water edge; thus the ebb and flow

covered or laid bare the beach for 15 rods. It is stated also, that previous to the rise a white squall on the lake gathered into a high water-spout, which swept rapidly to the east. A rumbling sound was heard coming from the water. Fish came to the surface of the lake in great numbers, and bubbles of gas rose rapidly and exploded. It was supposed there might be a submarine earthquake" (*Newspaper*, 1872).

IV. 1. Hurricanes, as storm-workers, kill fish under certain circumstances; and a water-spout sometimes whisks a shoal out of shallow water and distributes them elsewhere as a "rain of fish."

2. Storms kill multitudes of fishes, molluscs, etc., either by beating them to death or by burying them in sand and shingle. Brady, Crosskey, and Robertson say (*Palæontograph. Soc. Monograph of the Post-Tertiary Entomostraca*, 1874, p. 82), "After every great storm there is probably some change in the habitats of the mollusca."

3. A great storm in March or April, 1874, killed millions of Oysters at Arcachon, on the coast of France (*Newspaper*).

4. The late A. Leith Adams described in 1868 (Quart. Journ. Geol. Soc. vol. xxiv. p. 303), the result of a heavy gale setting up the Bay of Fundy, into Anderson's Cove, and thence into a small narrow-necked lagoon, on 26th September, 1867, driving before it myriads of small fishes and killing them by violence, beating, bruising, smashing, and suffocating such quantities that they lay a foot thick on the banks. "With the exception of a few Mackerel and New York Flounder (*Platessa plana*), this vast host belonged to one species, the *Clupea elongata*, or American Herring, and [the fishes] averaged about six inches in length." After some further observations on the enormous quantity of fishes, the peculiarities of the scene, and the effects of the storm, the author proceeds to observe, "To the geologist such accidents as the above cannot be otherwise than intensely suggestive. Here we have the Devonian and earlier Palæozoic rocks covered with Glacial Drift, now being overspread by a marine deposit in which enormous quantities of one species of Fish, in every possible state of integrity and mutilation, are mixed up with Mussels and other recent shells, Crustacea of large dimensions, tests of Echini and other Radiata, Annelids, Plants, etc., etc. The majestic tidal wave, as it rushes up the Bay of Fundy, will soon cover up these remains; and in the far distant future mayhap some geologist may speculate on the causes that brought about this wholesale destruction of so many Fish, just as we are lost in wonder and astonishment how and by what manner of means such-like phenomena took place in many instances among the Devonian and Carboniferous systems of this and other continents."

V. Fishes may be suffocated for want of oxygen when massed together in frightened shoals,—as they are in nets,—also when burrowing in sand and mud and accidentally buried by other sands and mud.

1. In the "Geologist," vol. ii. 1859, p. 216, is the following extract from a paper entitled "A Week in Gaspé," by Dr. J. W. Dawson, in the "Canadian Naturalist."

"On the long sand-point that, stretching far into the bay, shelters the harbour along which we walked in search of Whales' bones and shells, I observed an appearance new to me, and of some geological interest. Shoals of the American Sand-launce (*Ammodytes Americanus*), a little fish three or four inches in length, had entered the bay, and, either seeking a place for spawning or for sheltering themselves from their numerous enemies, had run into the shallow water near the Point, and, according to their usual habit, had in part buried themselves in the sand, which they throw up by means of their long pectoral fins. In this situation countless multitudes had died or been thrown on shore by the surf, and the crows were fattening on them, and the fishermen collecting them in barrels for bait; acres of them still remaining, whitening the bottom of the shallow water with their bodies. It was impossible not to be reminded by such a spectacle of the beds full of Capelin in the Post-Pliocene Clay of the Ottawa,[1] and the similar beds filled with fossil fishes in other beds as far back as the Old Red Sandstone. Geologists have often sought to account for such phenomena by supposing sudden changes of level or irruptions of poisonous matter into the water; but such catastrophes are evidently by no means necessary to produce the effect. Here, in the quiet water of Gaspé Bay, year by year, immense quantities of the remains of the Sand-launce may be imbedded in the sand and mud without even a storm to destroy them. Similar accidents, I am told, happen to the shoals of Capelin; so that there is nothing to prevent the accumulation here of beds equally rich in the remains of Fishes with those deposits of Ichthyolites that have excited so much interest and wonder."

VI. Shoals of Fish are often driven ashore by fishes of prey.

1. J. B. Jukes noticed in Northern Bay, Newfoundland, on July 1, 1839, that live Capelin (*Mallotus villosus*) were washed on shore by wave-fuls; and on July 5th, at Buonaventura Head, he saw that the Capelin were chased by whales in the offing (*Jukes's Letters*, 1871, p. 60).

2. Fishes have been seen to be driven ashore by porpoises and other enemies on the south-eastern coast of Africa (*Captain Orr*, 1874).

VII.—Among other causes of wide destruction among Fishes and Molluscs are both too much and too little heat in shallow water.

1. J. Gwyn Jeffreys notes that the *Scrobicularia piperata*, living in mud, sometimes suffers from its long siphons being dried by too long an exposure of the mud to the summer sun.

2. We know also that freshwater ponds may be nearly or quite dried up in hot seasons, to the partial or total destruction of their inhabitants.

3. Some saltwater lakes, covering 26 square miles, did exist (but were to be drained) near Calcutta, which were full of water in September and October, but the waters went off in November and December, leaving the fish to die and putrefy (*The Reader*, Dec. 2, 1865, p. 630).

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[1] See Geol. Mag. Vol. I. p. 160.

4. In the summer of 1866 a shallow-water area in Morecamb Bay was full of dead and dying salmon, owing probably to the water being highly heated by the sun (*Newspaper*).

5. "*Mortality among Salmon.*—During the last three or four days the residents in the neighbourhood of Rockliffe and Burgh Marshes have witnessed the recurrence of an extraordinary phenomenon connected with the *Salmonidæ* of the Solway. After each tide the shore has been found strewed with dead and dying salmon and salmon trout, presenting no indication of the cause of death. We have heard of some 50 fish being found on the sands of Rockliffe Marsh, and we believe that on the Burgh Marsh side of the river a much larger number have been picked up. It will be remembered that a similar occurrence took place last year, when various theories were put forth as to the cause of death. The fact, however, that the mortality of last year was accompanied by the same conditions of weather and water as that of this year seems to settle the doubt as satisfactorily as probably it ever will be settled. During the whole of last week the Eden had fallen unusually low; the tides were also low; while, at the same time, the weather was exceedingly warm. The chronicler of meteorological observations at Silloth records 'a week of brilliant summer weather, sky almost cloudless; solar radiation great, and atmosphere very dry.' The sun would, therefore, play with unwonted power upon the shallow water at the mouth of the Eden, raising its temperature, and sickening its finny inhabitants even unto death. There is little doubt, in fact, that the fish left by the tide have either died of a sun-stroke, or have been so much sickened and weakened by the action of the sun as to be unable to get away with the receding tide" (*Carlisle Journal*).

6. "*The French Oyster Harvest.*—For some time fears had been entertained that the oyster-beds on the west coast of France would suffer from the intense heat prevalent throughout Europe, but the most despondent owners had not anticipated so complete a disaster as that which has overtaken them. It is now certain that the harvest of this year will be a total failure; in many cases the beds are entirely depopulated, and their owners ruined. The damage to individuals is estimated at over 2,000,000f., and the Government will also be a heavy loser. The effect on the Paris prices has been very marked, many restaurants charging from four to five francs a dozen. From Arcachon a very singular result of the heat is reported, which at one moment threatened to produce a regular pestilence. The muddy shore near that place is at low water the resort of innumerable eels, which bury themselves in the slime till the return of the tide. The excessive heat, by drying up the mud, had killed them in thousands, and the smell of their dead bodies, washed up and down by the tide, was beginning to spread fever in the neighbourhood. A large number of fishermen were therefore engaged to collect them in heaps on the beach, whence they were carted inland and buried. The total amount thus disposed of was over 400 cartloads" (*Newspaper*, August, 1869).

VIII. 1. Hugh Miller long ago observed the destructive effects of frost on Molluscs between tidal lines and at low water in severe winters.

2. It is stated that Oysters are killed by cold (at freezing-point) in less than three or four feet of water" (*Chambers's Journal*, No. 837, Jan. 10th, 1880, p. 29, etc.).

3. In the lower half of an ice-sheet, 8 feet thick, in Barrow Strait, Dr. P. C. Sutherland observed that "scores of small Fishes (*Merlangus polaris*) had been caught and cruelly detained, and starved to death," while "myriads of Infusoria and siliceous Algæ luxuriated in the utmost profusion" (*Sutherland's Journal of Capt. Penny's Voyage*, etc., 2 vols. 1852, vol. i. p. 224, and pp. 275-6).

IX. Diseases and parasites appear to be common evils among Fish. The Salmon, Gold Fish, etc., are known to suffer from parasitic Algæ.

1. "*Fish Disease.*—The fish in the Seine at Paris appear to be suffering from some malady. Large numbers are cast on the banks dead, almost in a state of decomposition, and cannot fail to render the water unwholesome for drinking purposes. Immense shoals also float on the surface of the river with their heads out of the water, and are easily taken by men who wade in the stream with nets and baskets. Such fish are, however, quite unfit for food" (*Newspaper*).

2. In a *Newspaper* dated August, 1867, it is stated that "The banks of the Lake of Constance are at the present moment covered with vast numbers of dead fish, the result of a malady prevailing among them. A similar epidemic recently prevailed in the waters of the Lake of Geneva."

3. A great mortality among the Fishes in the Gulf of Mexico is noticed in the *Annals and Mag. Nat. Hist.* ser. 5, vol. viii. p. 238, 1881, from an American *Journal*. For two years near Florida, along a belt of water at a small distance from the shore, but over a space of 200 miles, the water was brick-red in colour, and its surface covered with dead fish; so also was the beach; and in fishing smacks, with live fish in "wells," passing through this water all the fish were lost by death. After careful examination, the result arrived at was that the fish probably died from "more or less parasitic Algæ."

X. Miscellaneous causes of general death of Fishes and Molluscs.

1. As in small aquariums, so in ponds, when the proper equilibrium of living and dead organisms is disturbed, and the vegetation fails to use up the escaping carbonic acid, the animals of all sorts die and add to the black mud and noxious gases of decomposition. Such a result occurred in a piece of water at Claremont, in Surrey, the late Professor Tennant informed me.

2. "The occasional outbreak of a ferruginous spring from coal-workings will kill the river-fish for miles" (Geol. Mag. Vol. IX. p. 339, August, 1872).

3. We know that sewerage, limewater, and purposed poisons kill river-fish to a great extent. In hot countries poisonous trees and herbage fallen into water have been said to kill fish.

4. Lightning as a destructive agent. "That fish are stunned in

the water there is sufficient proof. In 1772 lightning attacked the River Doubs, near Besançon, and stunned the fish, which were floated along by the stream. In 1670 a lightning flash fell on the Lake Zirknitz, in Austria; and such a quantity of fish almost immediately floated upon the surface that the neighbouring inhabitants collected twenty-eight waggon-loads for manure" (*Chambers's Journal*, October 2, 1869, p. 688).

5. Though by no means so extensive in effect as any natural explosion of volcanic ashes, steam, and noxious gases, yet the operations of sub-marine explosions, by torpedoes, common blasts, etc., have analogous effects; and even in such experiments in lakes and rivers the workmen look out for the dead fish remaining near the place of the explosion.

In *Nature*, November 26, 1874, an explosion by means of nitroglycerine on the Oregon coast is mentioned by Mr. Chase, who states that many fish were killed thereby, and others were taken in a stunned state.

XI. Marine life surviving in freshwater lakes.

The changes that take place in a local fauna and flora by a marine lagoon being cut off and in time converted into a freshwater lake are in some degree analogous to the more sudden and extensive destruction of marine life, by the causes above mentioned; but many creatures gradually get accustomed to new conditions, and therefore the whole assemblage is not swept away at once. Many interesting notices of such occurrences have been made. See *Nature*, vol. i. p. 454; vol. xiii. p. 107, etc.

## III.—NOTICE OF NEW FISH REMAINS FROM THE BLACKBAND IRONSTONE OF BOROUGH LEE, NEAR EDINBURGH.—No. III.

By DR. R. H. TRAQUAIR, F.R.S., F.G.S.

### SELACHII.

### *Pleuracanthus gracillimus*, n.sp.

LENGTH of a typical spine $1\frac{7}{8}$ inches; greatest diameter, $\frac{1}{10}$ inch. The spine is thickest about half an inch from its proximal extremity, towards which it slightly contracts, while distally it tapers to a fine point; its contour is at first straight, then becoming gently curved backwards towards the apex. Transverse section at first round, but near the middle of the spine a flattened area commences, running along the posterior margin, and as this is followed onwards, a delicate median ridge appears, and is continued to the apex. Along the boundary, on each side, of this posterior area, a right and left row of denticles is seen extending from the apex to three-quarters of an inch from the base: they thus occupy a greater extent of the length of the spine than the area in question. These denticles are about 38 on each side, opposite, closely set, minute, their bases compressed and proportionally elongated, their sharp, conical points directed obliquely downwards. Surface of spine striated proximally by delicate longitudinal grooves, which become gradually lost towards the perfectly smooth apex.

As usual, a rounded central cavity commences at the base and extends towards the apex.

I accept, provisionally, Mr. J. W. Davis's amalgamation of the genera *Pleuracanthus* and *Orthacanthus*, Ag., the fact being that we have as yet no accurate clue to the genera of Carboniferous *Pleuracanthidæ*. The present species is evidently related, in its general form, to *Pl. robustus* and *denticulatus* of the last-named author,[1] as well as to *O. arcuatus* of Newberry,[2] though differing from all of them in the delicate adpressed form of the denticles. My collection contains three entire specimens and many fragments of this very pretty spine.

### *Pleuracanthus horridulus*, n.sp.

Length of the most perfect specimen which has occurred 1 inch, but the completeness of its base is doubtful; diameter, $\frac{1}{12}$ inch at apparent base; contour gently arcuated, tapering to a fine point; surface tolerably boldly striated for rather more than half the length of the spine, then becoming smooth, with occasional elongated punctures. Posterior or concave margin set, from the apex to one-third of the length from the base, with two rows of *proportionally large and prominent* sharp, recurved denticles. Of these there are eight or nine on each side. They diminish in size towards the apex, but *not in proportion to the attenuation of the body of the spine*, so that distally they may appear as long as the spine is thick. These two rows of denticles are placed so close together along the posterior margin of the spine, that when a specimen is, as is usually the case, seen lying on its side on the matrix, it is difficult to conceive that there is more than *one* row; nevertheless, on a portion of a spine which has started off, the presence of two rows is proved beyond all doubt, the denticles of each row *alternating* with each other.

This formidable-looking little spine bears a very considerable resemblance to the figure given by Prof. Newberry of *Compsacanthus lævis*, Newb.,[3] notwithstanding the obvious specific distinction that in the latter the denticles are more numerous, and diminish regularly towards the apex in proportion to the attenuation of the diameter of the spine itself. Prof. Newberry states, however, that in *C. lævis* there is only one row of denticles, and on this fact he has founded the genus *Compsacanthus*. The existence of two distinct rows, however closely placed, in the present fossil, necessitates its reference to *Pleuracanthus* (incl. *Orthacanthus*).

### *Cynopodius crenulatus*, Traq.

*Cynopodius crenulatus*, Traq. Geol. Mag. Dec. II. Vol. VIII. p. 35.

Besides the typical and most abundant form of this strange spoon-shaped body which I described in a previous communication, specimens not unfrequently occur which are aberrant in their contour. In some of these, while the general shape is similar to that of the ordinary type, the radiating grooves and marginal crenulations of the expanded portion are wanting or obsolete, while the surface is also deficient in the usual glossy ganoine layer, and is dull, and more or less roughened by minute pores and short wavy grooves. In some of these cases the expanded portion is abruptly truncated. There is, however, no ground whatever for considering that any of these varieties in form are indicative of specific difference.

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[1] Quart. Journ. Geol. Soc. xxxvi. 1880, pp. 330 and 334.

[2] Pal. Ohio. vol. i. p. 332, pl. 40, fig. 4.

[3] Pal. Ohio, vol. i. p. 332, pl. 40, figs. 5, 5*a*.

*Cynopodius crenulatus*, besides occurring in the Borough Lee Ironstone (Carboniferous Limestone series), is found also in the underlying Calciferous Sandstone series of the Edinburgh district, as at Straiton Brick work (Mr. J. Gibson), Straiton Old Shale works (coll. of the author), Inchkeith (Mr. James Gaul), Pitcorthy Shale works (Mus. Sc. and Art Edinb.).

### *Gyracanthus formosus*, Ag.

The opinion that *Gyracanthus formosus* and *tuberculatus* of Agassiz are not specifically distinct from each other, having been expressed by more than one author, and I myself not having any particular reason for dissenting from that view, I catalogued the *Gyracanthus* spines, which are of such frequent occurrence in the Borough Lee Ironstone, as *G. tuberculatus*, in the list prefixed to my first paper on the fish remains of this bed. But whether the specific identity of these two forms be accepted or not, it seems to me, on reflection, necessary to preserve the name *formosus*, as it certainly occurs first in Agassiz's list, and may therefore claim priority.

It has long ago been pointed out that many at least of the spines of *Gyracanthus* were in all probability pectoral in their nature, by reason of their marked lateral curvature, and the frequency with which their extremities are found to be rubbed and abraded, as if they had been dragged along the bottom by a habitually ground-dwelling fish.[1] Messrs. Hancock and Atthey, however, still retained as probably dorsal a number of spines in which no lateral curvature is observable.

But Agassiz himself had already noticed another important circumstance connected with the want of lateral symmetry in *Gyracanthus formosus*. He says, "Leur coup est irregulière, l'un des côtés étant un peu plus renflé que l'autre."[2] This asymmetry of form is well marked in the Borough Lee specimens. Along the anterior aspect runs a line from which the ornamental ridges diverge, along the posterior is a keel or ridge set with small, closely placed, recurved denticles, and ending on one side of the extensive basal excavation. The lateral distance between these two lines is greater on one side than on the other, so that, in transverse section, one side is seen to be more gibbous, the other narrower and flatter: moreover, on the gibbous side a well-marked shallow longitudinal excavation or groove runs along immediately contiguous to the denticulated ridge. In fact, this groove appears to correspond to the posterior flattened area of such spines as *Ctenacanthus*, but set on awry, and having only one of its boundaries prominent and denticulated. It is also to be noted that the grooved and gibbous side of the spine always coincides with the convexity, the narrow and flattened side with the concavity of the lateral curve. That the spines showing this remarkable want of bilateral symmetry were paired and not median, there cannot be the smallest doubt.

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[1] Hancock and Atthey, in Ann. and Mag. Nat. Hist. (4) vol. i. 1868.

[2] Poissons Fossiles, vol. iii. p. 18.

## DIPNOI.

### *Ganopristodus splendens*, Traquair.

*Ganopristodus splendens*, Traq. GEOL. MAG. Dec. II. 1881, Vol. VIII. p. 37.

Since my first paper on the fish remains of the Borough Lee Ironstone appeared, I have obtained an important clue to the nature of the fish to which the singular dentigerous fragments belonged, which I then distinguished as *Ganopristodus splendens*. From these subsequent finds it appears that *Ganopristodus* was a fish closely allied to, and possibly generically identical with, the *Uronemus lobatus*, Ag., of the Burdiehouse Limestone.

The first specimen to be noticed is a mass of dislocated cranial bones, which for the most part, unfortunately, are quite unreadable. Lying amongst them, however, is a flat plate, evidently palatal in its nature, a considerable area of which adjoining the outer margin is closely covered with small rounded dental tubercles, by which apparently the roof of the mouth was roughened. The external gently curved margin of this plate displays a row of the brilliantly ganoid, laterally compressed, basally confluent, short conical teeth, characteristic of the detached fragments first noticed. Of the other bones it may be observed that some, which evidently belonged to the cranial roof, are ornamented externally by a tolerably fine reticulo-confluent tuberculation, having no trace of ganoine.

Previous to the occurrence of the last described specimen, my attention had been drawn to fragments, from the same bed, of the body of a fish closely resembling *Uronemus* in being covered with thin rounded scales, in having a well-developed internal skeleton consisting of long curved ribs, spinous processes and interspinous bones, but no vertebral bodies, and in the tail being evidently pointed and diphycercal with continuous dorso- and ano-caudal fin. One of these specimens also displays a portion of an acutely lobate ventral fin, with central scaly axis and fringing rays on each side. And lately I have succeeded in obtaining two entire specimens, in which this *Uronemus*-like body lies in conjunction with the *Ganopristodus* head.

The more instructive of these two specimens is about 12 inches in length, of which the anterior 3½ inches are occupied by the remains of the head. The head is crushed vertically, and on one slab is seen the impression of a considerable portion of the cranial roof, composed of polygonal plates, which, as shown by squeezes in wax, exhibit the same reticulate-tubercular ornamentation seen on the dislocated plates already mentioned. On the right side is seen the impression of the edge of the mandible with the characteristic teeth, and on the left the marginal teeth of the palatal plate, while in front, in the region of the snout, are seen other teeth similar in form but smaller in size. On the counterpart, the impressions of both palatal plates are seen *in situ*, each with its marginal row of large teeth, adjoining which a considerable area of the oral surface is roughened with small rounded tubercles, as already seen in another specimen. The two palatal plates are seen to meet, or at least to come very close together, in the median line in front. There is also the impression of a large opercular plate ornamented similarly to the bones of the cranial roof.

The commencement of the dorso-caudal fin is not exhibited, but posteriorly it becomes, like that of *Uronemus* and *Phaneropleuron*, of pretty considerable depth before it declines to the caudal extremity. Its rays are fine, closely set, repeatedly dichotomising and apparently, towards their extremities at least, divided by tolerably distant transverse articulations. Evidences of an ano-caudal of similar structure but smaller extent are also visible in several specimens, and I have already mentioned the distinct presence, in at least one example, of an acutely lobate ventral. The bones of the internal skeleton are always much confused, but are evidently very similar to those of *Uronemus*. The scales are very thin, oval in shape, sometimes slightly truncated at one end, and of considerable proportional size, sometimes measuring half an inch in length by one-eighth in breadth: externally they are dull and smooth, but occasionally, especially on the attached surface, they display delicate concentric lines crossed by still finer radiating striæ.

A careful scrutiny of the specimens of *Uronemus lobatus*, Ag., in the Edinburgh Museum, reveals the fact that the teeth in this strange little fish are very similar in general appearance to those of the Borough Lee *Ganopristodus*, being in the form of low, laterally compressed cones, confluent at their bases and brilliantly ganoid, and taking the obvious similarity of the scales, internal skeleton, and fins also into account, it seems very possible that the two genera may be in reality identical. Unfortunately, besides the shape of the teeth, hardly anything is known of the cranial structure of *Uronemus*, and consequently I am inclined for the present to retain the name *Ganopristodus* for the Borough Lee fish. I may mention that I have seen no lateral serrations on the teeth of *Uronemus*, but these are not always present in *Ganopristodus*.

I must reserve discussion of the reasons for placing both *Uronemus* and *Ganopristodus* in the order Dipnoi for another occasion.

## GANOIDEI.

### *Strepsodus striatulus*, n.sp.

Teeth ½ inch to ⅞ inch in length, compressed, oval in transverse section, incurved, hardly geniculated at the apex, base with relatively coarse plications. The convex (external) margin of the tooth is quite smooth, the smooth area encroaching more or less on the sides of the tooth in different specimens. The concave (internal) aspect of the tooth, with more or less of the compressed surfaces, is ornamented with very delicate, closely placed subparallel raised striæ, which follow a direction on the whole similar to that in *Strepsodus sauroides*, Binney, sp., that is, while parallel with the direction of the lower part of the tooth, they do not follow the apical flexure, but pass vertically upwards nearly irrespective of it till cut off at the external smooth marginal area; these striæ are frequently bifurcated and intercalated.

My collection contains seven of these peculiar teeth, which differ slightly among themselves as to the degree of slenderness of their contour, amount of compression of the shaft, and extent of surface covered by striæ. I refer them, provisionally, to the genus *Strepsodus* on account of the pattern of their striation, and their compressed form, but they differ materially from the teeth of *S. sauroides* in the apex being scarcely geniculated or recurved, and also in the much greater fineness of the striæ.

Professor Young, in his description of *S. sauroides*, speaks of the smooth margin of the tooth as "anterior." But in well-preserved jaws of that species it may easily be seen that the great curvature of the tooth is inwards, not backwards,—the smooth margin is therefore *external.*

### *Elonichthys pectinatus*, Traq.

*Elonichthys pectinatus*, Traq., Proc. R. Soc. Edin. 1876-1877, p. 430; and Proc. R. Phys. Soc. Edin. 1879, pp. 113-128.

This magnificent Palæoniscid was originally described by me from rather fragmentary material from other localities: recently I have had the good fortune to obtain a specimen from Borough Lee, which shows the contour of the fish, though the greater part of the head is lost, and only part of the caudal fin remains. The total length of the specimen, as it now exists, is 16 inches. There can be no doubt that when perfect it must have measured at least 2 feet; but even this is small when compared with the size of specimens from other localities, whose length I have estimated, from their fragments, at from 3 to 4 feet. The depth of the present specimen, in front of the dorsal fin, is 4½ inches.

The scales agree in every respect with those which I have previously described as characteristic of the species. They are of moderate size, compared with the dimensions of the fish; the exposed area of those on the front of the flank being about ¼ inch in height, by ⅙ in breadth. The great interest of the specimen lies in the view which it affords of the general proportions of the fish, and the form and disposition of the fins. The shape is somewhat deeply fusiform, but from the deficiency at both extremities, fuller details as to proportions are impracticable. The pectoral fin is not shown in its entirety, its extremity being somewhat crumpled up, though it is clearly seen that its principal rays were unarticulated for about one-third of their length. The ventrals are placed midway between the pectoral and anal, and are composed of numerous rays, divided by articulations, which are at first distant enough to cause the joints to be rather longer than broad, though distally, where the rays dichotomise, they become closer. The dorsal commences opposite the middle of the space between the ventrals and anal, and is of considerable size, its height being 2½ inches, and equal to the extent of its base; its form is triangular, and sharply acuminate. The anal fin commences opposite the middle of the base of the dorsal, and, unlike what is usually the case in *Elonichthys*, differs decidedly in shape from the last-named fin, and comes to resemble the anal of *Pygopterus*, in being prolonged backward in a fringe-like manner. Anteriorly, the fin is sharply acuminate, its longest rays being about 2 inches in length; behind the apex its contour rapidly falls away, till about two inches from the commencement of the base they measure only half an inch; thence they are continued as a narrow fringe for 2 inches more, the entire length of the base of the fin being thus 4 inches, or twice the depth of the anterior part. Only a small part of the caudal is shown: it was evidently powerfully heterocercal. In all these fins, the rays are rather fine for the size of the fish, closely articulated, and exquisitely sculptured externally by oblique ridges and grooves. The marginal fulcra are very small and close.

### *Gonatodus parvidens*, n.sp.

In my first list of Borough Lee fish remains I indicated an undetermined species of this genus as "*Gonatodus*, sp.," and since that was published an accession of fresh material has convinced me that the species is new. *G. parvidens*, of which I hope to give a more detailed description afterwards, resembles *G. macrolepis*, Traq., pretty closely in its form, scales, and fins, but may be distinguished both from the latter and from *G. punctatus*, Ag., by the remarkably small size of the maxillary teeth, which, however, still retain the shape characteristic of the genus.

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## IV.—The Fallacy of the Theory of the "Permanence of Continents."

By J. S. Gardner, F.G.S.

It is rather remarkable that the Theory of the Permanence of Continents and Oceans has passed so comparatively unchallenged by geologists. I long since attempted to show that Mr. Wallace's supposition that the Chalk was a shallow and littoral sea deposit was untenable. In comparing analyses of chalk, as he does, with Atlantic ooze, no allowance whatever is made for the loss of iron from the body of the chalk by crystallization, nor for the segregation of silica into flints. The Chalk may have undergone so great a change in addition, since its upheaval vast ages ago, through the removal of some of its constituents by percolating water, that comparative analyses can only be of value when these losses are taken into consideration. The total absence of Globigerina, and almost all the Cretaceous fossils in the decomposed coral mud of Oahu, to which Mr. Wallace would assimilate our chalk, shows that they could not have been deposited under the same conditions; whilst the dissolution from the chalk of all its mollusca except the few whose shells were phosphate of lime, renders any inference drawn from them relatively untrustworthy, seeing that so many of the latter are extinct forms, about whose habits we can know nothing. The Sponges, Crinoids, and Echinoderms, as well as the microscopic organisms and structure, show the chalk to have been an oceanic deposit, uncontaminated with sediments from land. But quite apart from any question about the Chalk, there are many considerations which militate against his views.

The inconvenient presence of land-shells on the most remote islands is overcome by supposing that they have floated across oceans or that their passage has been due to some fortuitous chance during the great length of time they have existed; but since it is well known that islands so close to each other as Madeira and the Desertas and Porto Santo have each species peculiar to them, a narrow channel in the former case sufficing to keep them isolated, we can hardly admit that the great *Bulimus* of the Antilles, which with its eggs, swarm in the Bembridge limestone of the Isle of Wight, or that the Texas snail of Headon Hill, could have migrated across the Atlantic, especially in company with an entire flora of Central American plants to feed upon. To account for the presence of South American plants in Australia, they have to be taken across the Antarctic continent, which there is no ground whatever for supposing was ever fitted to receive them even in Tertiary times, and across thousands of miles of sea. During the Eocenes we have distinct migrations of plants from Australia and from Central America into England, and a migration from England to Greenland, and thence to North America. British Jurassic types are still preserved on islands as remote as Juan Fernandez and nowhere else, and others in Borneo and New Caledonia. All the land communications required to have existed during the Tertiary period coincide with banks and ridges, with islands occasionally rising to the surface, which cross the Atlantic and Pacific, and if these may not be supposed to be either rising or sinking land, what may they be supposed to be?

The fact relied upon that old rocks are rarely met with on Oceanic Islands, is simply that these are often volcanic or coralline, and as we cannot see through the crust that covers them, we cannot tell what their interior may be composed of. Among the islands enumerated in which old rocks do occur, the Bahamas, St. Thomas, Falkland Isles, and New Caledonia are omitted, though these are all mapped as being at least partially formed of old rock. Without wishing to disturb the *greatest depths* of the ocean, I see no reason why changes of level exceeding 1000 fathoms should have been physically impossible during all past geological time. Theories demanding the least amount of change jar least with popular ideas, and are naturally the most readily accepted; but, although no one would wish to deny that Mr. Wallace is able to explain in the most convincing manner the present distribution of such recently evolutionized beings as the existing species of birds and mammals, geologists can still avail themselves of submarine ridges, no matter at what depth, to explain the interchange of species in the past. After long reflecting on the subject, I think we need not hesitate to avail ourselves of them to the fullest extent; and I decline to believe that the existing or even the Quaternary distribution of birds and mammals throws much light on the physical geography of the earth when birds were still toothed, and even the primary groups of mammals were scarcely differentiated.

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## V.—Woodwardian Laboratory Notes, N. Wales Rocks III.

By E. B. Tawney, M.A., F.G.S.

(*Continued from Vol. VII.* 1880, *p.* 458.)

At Penyrhiwan, Clynnog, in the middle of fields, is a protruding boss of dark-coloured rock which has been well broken into, in order apparently to see whether it was available for making "sets" or pitching stones, which form the staple trade of the adjoining district. Its surface is well rounded, as if by glaciation. The boss consists of at least three varieties of rock. Most noticeable is a coarse-grained hornblendic one of handsome appearance, the glistening cleavage planes of the brown hornblende standing out from the remaining green actinolitic portion. A second variety is a fine-grained greenstone, which is separated from the preceding by a hard definite line, so that it may be taken to be of the nature of a dyke intruded into it.

A thin slice was taken at the contact so as to show the absolute junction. In the coarse-grained hornblendic rock microscopic examination showed that felspar was almost absent, there was only a very little decomposed pseudomorph that could be put down to this species. The rest consisted either of brown hornblende which passed by all variations into green actinolite of various shades, or decomposition products of the above, chloritic and viridite substances. Apatite is present inclosed in hornblende. Moreover, some secondary brown mica exists pseudomorphing hornblende apparently. The rock to the unassisted eye is very much like one collected by Sedgwick as a loose block under Girn Goch, and a similar rock is much used in the walls. That described however by Prof. Bonney [Cl. 15, Sedgwick Coll.], Geological Magazine, Decade II. Vol. VII. p. 457, does not quite agree with ours. Our slice has no augite, while Sedgwick's has abundant octagonal sections of augite showing its cleavage.

Possibly, however, both have come from the same spot, for there is no other greenstone rock mapped by the Geological Survey near here, nor have we been able to find any. We may perhaps assume that the rock varies in different portions, sometimes augite being present, sometimes not. The present case taken at the junction may be considered therefore a hornblendic-diabase, in which augite happens to be absent, and the felspar at a minimum.

The dearth of felspar gives the rock an outward resemblance to pikrite, which is also kept up by the dark inclosures which break the reflection of light from the cleavage planes of the hornblende, but we have been unable to determine any olivine pseudomorphs among these.

The fine-grained rock at the immediate junction is seen to be a diabase. The plagioclase prisms are set mostly parallel to the junction face, and are much decomposed; the augite is entirely so, only tracts of viridite represent it; the ground is darkened by the quantity of magnetite grains, while between them is a greenish-grey granular substance, probably the remains of decomposed felspathic substance and chlorite.

The third variety of rock is a medium-grained diabase with some hornblende, or proterobase as some might call it. I could find no hard junction between it and the coarse-grained rock, and though such may be hidden among the furze, it seems to me more likely that the one rock passes gradually into the other; I infer this from the relative position of the two kinds at their outcrops among the vegetation.

The chief constituents are augite in large crystals inclosing felspar, etc., and plagioclase; some of the augite is quite fresh, but there are many patches and aggregates of decomposition products, viridite, etc., which must be put down to it; the plagioclase is also very much decomposed, and was apparently rich in lime from the calcareous look of its products. There is a little green hornblende with basal sections giving the characteristic cleavage, but it is in a minority. Brown mica is also present connected with ferric stains and other decomposition products: whether the mica is in an incipient stage—just forming, or whether it is a remnant decomposing—I am not sure. The ferric stains are also accompanied with opaque black oxide (ilmenite?).

From the minute quantity of hornblende this rock seems quite different to the coarse-grained, yet it is quite possible that there are intermediate passages at Penyrhiwan. The case would be only similar to that which Dr. E. Reyer of Gratz describes (as "Schliere") in massive eruptions. We may mention the case described by Prof. Geikie of pikrite passing into diabase at Blackburn near Bathgate (Trans. R. Soc. Edinburgh, vol. xxix. p. 507).

The Penyrhiwan boss is apparently protruded through the Cambrian shales, the exact age of these I am not able to give, not having found fossils.

*Carn Boduan.*—In 1878 I had the advantage of accompanying Dr. Hicks when he collected the specimens from this hill, and which were determined for him by Prof. Bonney [Quart. Journ. Geol. Soc. vol. xxxv. p. 305], as a quartz-felsite or quartz-porphyrite. A quarry a few hundred yards to the east, but also on the south side of the mountain, visited at that time, yielded us a rock which on examination I found to be a porphyrite. As Dr. Hicks seems to consider these only as dykes, since the hill is included in his Arvonian in the sketch-map [*ibid.* p. 297], I felt a desire to examine the hill more closely. Accordingly in 1880 I collected from various points round the hill, and also from the summit.

We will describe first the rock of the quarry a few hundred feet east of the turnpike on the south side of the hill. In the hand specimen it is a black glistening rock with small separate felspar crystals.

Under the microscope the felspar is found to be all plagioclase fairly clear and fresh, the extinction angle on either side of the twin face being small, points to their being oligoclase. The ground contains some glassy base in interstices, but is made up chiefly of plagioclase microlites with calcareous patches of decomposition, and a crowd of magnetite particles, giving doubtless the dark colour to the rock. Separate crystals of green hornblende are fairly numerous, and with them are a few crystals of augite. Largish crystals of black oxide of iron (ilmenite?) are often connected with the hornblende; apatite, which is abundant, is usually in the same connexion. This is a freshly-preserved porphyrite with andesitic structure. While the rock at one side of the quarry is nearly black, at the other side may be found a pale greenish variety in which are occasional segregations of crystalline calcite up to an inch in diameter. It is, however, only the same rock weathered. A slice off a specimen in the Sedgwick Collection [P. 59] is to be referred here. Its felspars are nearly entirely decomposed, the hornblende has disappeared, as have also the small felspar prisms of the ground, their place being taken by nuclei or patches of crystalline calcite showing cleavage and twinning; the ground is largely occupied by a greyish-brown granulated material, which runs together into most involved forms; under high powers it is seen to be not opaque, but to polarize very feebly, probably several decomposition products enter into its constitution. Very minute grains and nests of secondary quartz lie in its folds. Apatite alone remains unchanged.

Another example collected by me shows an intermediate stage of decomposition, and serves to explain the great change wrought in the arrangement of the rock by decomposition. It would have been impossible to determine the extreme case unless it had been recognized as coming from this quarry, in which all stages are found. This porphyrite may be found to extend for some hundred yards in breadth. Turning to other parts of the hill, we find it composed mostly of a fine-grained grey rock, not so dark as the porphyrite of the quarry just mentioned; it contains minute felspars; when weathered, however, it becomes a brownish-grey, more or less speckled with felspathic portions of pale ochrey tint. It may be recognized as having to the eye the same characters all over the hill. Examples of it from various points were submitted to microscopical analysis, the specimens chosen being as little weathered as was possible to obtain.

Carn Boduan, from quarry on west side of hill by the encircling wall.—This is a fine-grained rock, quite compact-looking, of a more greenish-grey tint than usual. Under the microscope it is seen to be much decomposed, the larger felspars almost entirely converted to aggregates of variegatedly polarizing particles. The ground has the same structure as that of the first-mentioned quarry, consisting of microprisms of elongated form, their long axes here being often parallel; they are less decomposed than the larger ones, and extinguish in a way which proves their triclinic nature; some of their outlines are, however, merged into decomposing material, though enough remains to show their general fluidal arrangement. There is similarly amorphous base between the crystals, partly globulitically devitrified. Calcite aggregates and scattered specks are distributed through the ground, and permeate the felspars. Of hornblende there is nothing left but small shapeless patches of chloritic material. Magnetite grains occur throughout the ground. This rock is evidently a porphyrite of the same type and composition as the blacker one above described.

Carn Boduan, from the base on south side near the turnpike.—The rock here is a fine-grained grey rock weathering brownish-grey. This is from the same spot as Dr. Hicks's specimen [Q.J.G.S. vol. xxxv. p. 305], collected in 1878. It is somewhat less decomposed than the last, but has much the same structure. The ground is microcrystalline, with interstitial glassy base; it consists of plagioclase microprisms, the extinction on each side of the twin boundary measured in some cases as 3°–4°; the parallel arrangement is not so marked as in the last case. The microprisms preserve their twinning better than the larger plagioclase crystals, which are partly changing into calcite by patches, in which cleavage is sometimes developed. There are also aggregates of calcite in the ground. No hornblende has escaped decomposition; some chloritic patches beset with magnetite indicate its existence, but generally the viridite or chloritic matter shows no definite shape, and is almost apolar. Magnetite grains as in the other cases.

The rock at the summit of Carn Boduan has the same appearance as that at the base, being a fine-grained grey rock weathering brownish-grey. I found it at the summit inclosing a dark black-grey piece of a different rock, looking like a piece of shale which had been converted into a sort of lydianite. This specimen was sliced and examined with the microscope. Its outline is sharp such as an inclosure would have.

Under high powers the numerous closely-crowded brown particles, which look half opaque, are broken up into aggregates of yellow scales which seem to be epidote, together with black-brown grains, which are magnetite changing into a higher state of oxidation; between are very minute grains of quartz. There are also some angular brown dichroic scales about $\frac{1}{60}$ mm. which seem to be mica. The square magnetite grains and the rounded yellow scales are from $\frac{1}{250}$ mm. to a little over $\frac{1}{100}$ mm. on an average. Under a power of 50 diameters, in which these details are not to be seen, numerous groups of epidote crystals are seen scattered through the rock, and also minute garnets of about $\frac{1}{17}$ mm.; there are also smaller garnets visible with high powers, so that they in size vary from $\frac{1}{17}$ mm. to $\frac{1}{100}$ mm.; they inclose magnetite particles. It seems probable that this is an inclosed fragment, in which garnets, etc., have been produced by the contact-action of the porphyrite.

The rock immediately inclosing the said fragment has the same microscopic characters as that from previously described parts of the hill: the plagioclase microprisms are here set parallel to the line of contact. Much secondary epidote is developed, this and viridite are scattered throughout the ground, but none of the original hornblende is preserved.

Hence we consider the whole mass of Carn Boduan to consist of grey porphyrite. The principal divisional planes of the rock are nearly vertical; this is well seen in walking over the hill, or even from below on the W. side, the vegetation finding root in the cracks accentuates this feature; these planes strike N. 25 E.—S. 25 W. Notwithstanding its being opposed to Dr. Hicks's remarks [*l.c.* p. 299], I must advocate a return to the view of the Geological Survey. There is every appearance of the mass being an intrusive rock protruding through Cambrian shales, which are seen lying at a steep angle in the vicinity; I could not find an actual junction. Plainly the rock is not metamorphic, it has the jointing and structure of an igneous rock throughout. Microscopic analysis applied to pieces from various parts of the hill confirms this view, so that there is every appearance of its being an intrusive boss.

I pass now to the consideration of a series of igneous masses which extend with more or less interruption from Nevin to Clynnog. Most of these are included by Dr. Hicks among his Pre-Cambrian series; he in the text acknowledges the partial intrusive origin of one of the Yr Eifl hills [*l.c.* p. 299] on receiving Prof. Bonney's report on the rock from Trevor quarries, but in the sketch-map they seem included as Arvonian. It seems to me, however, that there is sufficient evidence that these are all igneous rocks intruded through Cambrian shales in the manner delineated on the map of the Geological Survey. These rocks, though diversified in colour, appearance, and grain, vary chiefly between granite-porphyry and syenite-porphyry to porphyrite or diorite. They are called "felspar-porphyry often syenitic" on the Survey Map (and sometimes diorite in the text), which well expresses their appearance.

To begin with the mass about one mile N.E. of Clynnog at Cil y Coed; this is a quartz-felsite of pinkish-grey colour, with some green patches, the quartzites more numerous than the felspar crystals. Some of the latter are seen with a hand lens to have triclinic twinning. It is of a different type of rock to the following.

Bwlch Mawr, a hill S. of Clynnog, from the N. side of the hill below the summit.—The ground is dark grey, and looks fine-grained to the eye; in it are scattered numerous whitish felspars averaging about $\frac{1}{7}$ inch in diameter. Even a hand lens shows that many are plagioclase.

The microscope confirms the fact that many of the larger felspars are plagioclase, and from the predominance of crystals with a small extinction angle, they should belong to the oligoclase group. The ground was apparently microcrystalline, but it is now so decomposed that not much is to be made out. Under crossed Nicols there are clearer spaces of doubly refracting matter rendered turbid by fine dust, and darker granulated interstitial matter which seems almost optically inert; a few nests of quartz seem due to secondary action. Magnified only fifty diameters, part of the ground is found heaped together to form dirty grey granulated more or less opaque areas, which is an effect of decomposition. Apatite exists, and a few small crystals of secondary epidote. There is some ilmenite covered with leucoxene. If any bisilicate existed, it has decomposed. The effect of decomposition is to give a quite different appearance under the microscope to that taken from the top of the hill. The hand specimen looked, however, fairly fresh, and in appearance much like the rock of Girn Dhu quarries.

(I regret that we are unable to offer any chemical analyses of these rocks, but in our present locale we have no facilities for carrying out such.)

(*To be continued.*)

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## VI.—TRACES OF A GREAT POST-GLACIAL FLOOD.

### 5. EVIDENCE OF THE MARINE DRIFT.

By HENRY H. HOWORTH, F.S.A.

THERE is an unfortunate Nemesis attaching to great discoveries and generalizations, which has not been sufficiently noticed. When men have been floundering about for years in a quagmire of confusion and difficulty, and some brilliant pen points out a clear way by which the tangle may be threaded,—a way which is so ingenious and simple that it at once seizes upon the current scientific thought, and compels the adhesion of everybody,—it inevitably produces a period of stagnation and for a while dwarfs inquiry. What is so palpably true and simple as the explanation of a very perplexing difficulty is taken to explain *all the difficulty*, and, for a while at all events, men's energies are devoted to bringing every apparently aberrant and stubborn fact within the new law or the new process; and every effect, however remote, is traced by a direct way or by a zigzag to the prime cause which has proved so fruitful. It is only after an interval, when men have digested and incorporated the new theory into their daily creed, and it no longer overawes them by its freshness, that they are in a mood to ask soberly whether, after all, too much has not been demanded from one cause,—whether, after all, the intricate and far-fetched explanations, which are necessary to connect that cause with effects with which we are familiar, is not illegitimate,—and whether we must not supplement it by some other cause, which has modified and altered its work, if we are to solve the whole riddle. A very admirable concrete example of the matter we are discussing may be found in the Glacial Theory. When the Glacial Theory was proposed by Agassiz, working on the lines of Playfair, to explain the rounded and polished surfaces we find in Scandinavia and Scotland, the striated and furrowed rocks, and the vast congeries of boulders of all sizes that strew the surface of Northern Europe, it was felt that one of those critical turns had been taken in Geology which enable us to map out a vast and complicated field with precision. Since this turn was taken it is surely no exaggeration to say that the history of so-called Quaternary Geology has been the history of the efforts made to explain every kind of problem presenting itself in the surface deposits of Northern Europe by reference to the Glacial Theory; and the time has come when the question may fairly be asked, whether the pendulum has not swung a great deal too far in one direction, and whether the position of equilibrium demanded by the difficulties of the hour do not demand that it shall swing back again through a considerable arc. I believe that there is only one answer to this question, if we are to progress at all. Let me not be misunderstood. I do not wish to minimize the forces which polished and rounded the surface of so much of Northern Europe, which made the boulders and ground the clay. On the contrary, I believe that they were so important that we have a great deal yet to learn before we shall appreciate them. But, on the other hand, I cannot approach the very critical difficulties presented by the Northern Drift, and its associated deposits, bound hand and foot to a theory which would attribute every peculiarity in the distribution and contents of the loose deposits of Northern Europe to the action of Glacial forces; forces which are characterized by results only explainable when we treat them as intensely destructive, and which are inconsistent with the more conservative results we meet with in various directions. The conclusions which follow, and which seem to me overwhelming, are dictated by a study of the so-called Glacial Beds themselves, and are not mere inferences from what we have seen reason to conclude from other data; and if they agree with the results of such inference, it only makes the case so much stronger. What is meant by and involved in Glacial conditions? When we speak of certain beds of shells being glacial, of certain gravels and sands being glacial, what meaning do we attach to the words? The Glacial Period, properly so called, during which the mountains of Scandinavia and Finland, of Scotland and Wales, were rounded and polished and striated, during which the vast streams of boulders of all sizes that are scattered over such districts as Finland and Smaland, and are distributed in more sporadic fashion over a vast area elsewhere, were rounded and grooved,—a Glacial period when Ice produced results of this kind, and on this scale, can only be matched, if it can be so matched at all, by what is taking place now in the interior of Greenland, or in the basins of the Arctic and Antarctic seas, where gigantic masses of ice are perpetually present, grinding and denuding the surfaces on which they rest, where the whole coast is lined with ice, and every inlet and fiord choked with a glacier—and this over a very wide area. Such a state of things is quite inconsistent with long stretches of beach free from ice, of inlets so free that the most delicate and fragile shells could live freely on their bottoms and along their sides,—is quite inconsistent with such a state of things as prevails now in the seas bathing the Shetlands, the Orkneys, the Faroes and Iceland. We have no glacial conditions at all in these areas, nothing approaching, even qualitatively, what took place during the Glacial Period properly so called. This is a very important fact to remember in the discussion which follows. If by a glacial shell is meant a shell now thriving in that part of the North Atlantic bounded by Iceland, Norway and Caithness, then I say such a description is a complete misnomer and most misleading.

Just as misleading as to apply the term Glacial period to a period when the land was occupied by the Fig and the Hippopotamus, and the adjoining rivers by the *Cyrena fluminalis.* The molluscan fauna of the Glacial period proper must be sought for in the Palæocrystic Sea, and not in the always open North Atlantic. My own view is that when the Glacial period proper was current, the conditions were such as to make life virtually impossible in the districts where it prevailed, and to drive living things, both animals and plants, elsewhere. This *à priori* view is amply confirmed by the geological evidence.

Mr. Crosskey, in the Transactions of the Glasgow Geological Society vol. ii. p. 47, speaking of the section at Lochgilphead, says, "Nothing can be more striking than the change from no life in the Boulder-clay to abundant life in this bed (2, the shell-bed) immediately on it." In the section in the Kyles of Bute, he says, "Fossils might appear to an inexperienced observer to be in the Boulder-clay, when they really occur at points where the fossiliferous bed is in immediate contact with it" (*id.* p. 49). Again, one of the conclusions to which he calls special attention, as the result of his examination of the beds in question and others, is, "That the Boulder-clay proper, at the base of the series, is destitute of fossils. A number of cases in which fossils were said to occur in the Boulder-clay have been examined, and it has been found that they were either beneath it or that an upperdrift has been confounded with it" (*id.* p. 51). Again, speaking of the beds at Paisley, Messrs. Crosskey and Robertson say, "In the Boulder-clay itself we have not yet succeeded in this neighbourhood in finding any signs of life" (*id.* vol. iii. p. 337). Speaking of these same Paisley beds, Dr. Fraser says, "Underlying all was the old Boulder-clay or Till, the conditions of which were altogether unfavourable to life. It represented a cold, bleak, and in part tumultuary period" (*id.* vol. iv. p. 178).

I select these passages because they are in the first place from writers who are deservedly esteemed authorities on these beds, and secondly because they refer to a district where their true sequence and history, as it seems to me, can best be followed.

Let us now proceed. When the glacial conditions proper abated, and a condition of things ensued which was rather that of the seas about Southern Greenland and Iceland than of the Palæocrystic Sea, molluscs of a certain type no doubt invaded the more suitable waters. We actually find in Britain and in Scandinavia that the azoic Boulder-clay proper is followed by beds containing Northern forms of shells, and that as we trace these beds upwards we gradually meet with a molluscan fauna of a more and more temperate character. The series can be well studied, as has been shown by Mr. Crosskey and his colleague, in the Clyde and neighbouring beds. This position is so well accepted now as to be hardly arguable, and is well stated by Mr. Crosskey in the following sentence, "The fossiliferous clays and sands belong to several ages; and the fauna usually catalogued together must be separated into distinct groups, each referable to its own bed, and having its own place in the gradual transition from a severely arctic to a more moderate temperature" (Trans. Geol. Soc. of Glasgow, vol. ii. p. 51). I am tempted to quote a passage, describing the condition of things when life first crowded the previously glacial seas, from an observer who did rare work as an explorer, namely, Dr. Robert Brown. Speaking of the clay now forming on the coasts of Greenland by the deposit of its contents by the subglacial streams in the open sea, he says, "In this clayey bed the arctic mollusca and other marine animals find a congenial home, and burrow into it in great numbers. However, as new deposits are thrown down, they keep near the surface to be able to get their food" (Physics of Arctic Ice, by Brown, Journ. Geol. Soc. vol. xxvi. pp. 682–3).

The feature which specially characterizes the marine fauna of the Polar Seas is the paucity of species which prevails there. Forbes long ago pointed out "that a deficiency in species and individuals of the testaceous forms of mollusca indicates, to the marine zoologist, the probability of a state of climate colder than that prevailing in the same area at present." "Thus," he adds, "the existing fauna of the Arctic Seas includes a much smaller number of testaceous mollusca than those of the Mid-European seas, and the number of testacea in the latter is much less than in the South-European and Mediterranean regions. It is not the latitude but the temperature which determines these differences" (Forbes, Mem. Geol. Survey, vol. i. p. 367). There can be no doubt that the general evidence goes to show that the marine climate was colder during the deposition of the immediately Post-Glacial beds than it is now; but, as we shall show presently, this has been much exaggerated and misunderstood.

Everybody will admit that the Memoir just quoted was one of the most remarkable and suggestive which was ever published, and that it marks a great epoch in palæontological and biological generalization. The greater portion of this Memoir, as is well known, is taken up with an examination of the molluscan remains found in the various drift deposits of the northern part of Great Britain, which Forbes assigns to the Glacial epoch, speaking of the waters in which they lived as the Glacial Sea, and of themselves as Glacial Testacea. Forbes defines what he means very explicitly. He says: "By Glacial epoch I intend to express that section of geological time which was typically distinguished by the prevalence of severe climatal conditions through a great part of the Northern hemisphere, and during which those marine accumulations, in part truly sedimentary deposits, which have been called Northern Drift, were formed. I have selected the word 'Glacial' in order to remind geologists of the ice-charged condition of our seas during that epoch, conditions which probably did not prevail during its earlier stage, and the gradual disappearance of which marked its conclusion" (*op. cit.* pp. 402 and 403).

It is a bold thing to question the position of such a conchologist as Edward Forbes, and it would be a practically hopeless one if he and those who agreed with him did not virtually furnish us with weapons out of their own mouths. The whole point that I wish to raise is as to the connotation of the term Glacial as used by

Forbes and his successors. Do they mean a sea choked with ice, where all the fiords and coasts were lined with ice; or do they mean merely an open sea, where the climate was generally colder than that in St. George's Channel and the North Sea at this moment, and corresponding rather to the seas on the coasts of Northern America and Scandinavia? If the former,—and certainly the former is the meaning of the term Glacial Sea in the mouths of several of his followers,—it seems to me that the facts are overwhelming against the position. If the latter, there is no quarrel of any kind; for the position is apparently impregnable.

Forbes professes to tabulate the results of the examination of the so-called Glacial marine drifts up to the moment when he wrote, as they occur in North Wales, Cheshire, Lancashire, the Isle of Man, the Valley of the Clyde, and Caithness, and he tells us the number of shells known up to that time was about 124. "With few exceptions," he adds, "they are all forms now existing in the British seas." It is most pertinent and interesting to quote his tabulated results of the examination of these shells. He divides them into six classes.

First, species now living throughout the Celtic region in common with the Northern seas, and scarcely ranging south of the British seas. Of these he enumerates twenty-five species. Secondly, species which range far south into the Lusitanian and Mediterranean regions, but which are most prolific in the Celtic and Northern seas. Of these he enumerates twenty-four kinds. Thirdly, species still existing in the British seas, but confined to the northern portion of them, and mostly increasing in abundance of individuals as they approach the Arctic circle. Of these he gives fourteen. Fourthly, species now known, living, only in European seas north of Britain, or in the seas of Greenland or Boreal America. Of these he gives sixteen species. Fifthly, species not now known existing, and unknown fossil in previous deposits, six species. Sixthly, species, fossil in the Coralline or Red Crag, but still existing in the South-European, though not in the British seas. Seventhly, extinct species, fossil also in the Crag.

If we exclude classes 5, 6, and 7, as containing unknown factors, what is the result of this tabulation? That sixty-three species are found still living in the British Seas in our very temperate climate, and only sixteen are confined to the European Seas north of Britain, or the seas of Greenland and Boreal America. Surely this is suspicious evidence upon which to found a postulate that these shells lived under glacial conditions only. But let us examine these 16 species somewhat more closely.

I. Mr. J. Gwyn Jeffreys gives *Astarte multi-costata* as a mere synonym for *Astarte compressa,* which shell in its typical form he tells us occurs off Scarborough and off Mull, while of its three varieties, *A. globosa* is common off Skye, and the coasts of Argyle and Ross and East of Shetland; *A. striata* is plentiful on the coasts of Yorkshire, Northumberland and Durham, the Firth of Forth, the West of Scotland, and the outer Hebrides; while *A. nana* is found 15 miles N.W. of Mull. And of the species in general he says: "*A. compressa* and particularly the variety *striata* is extensively distributed throughout the North Atlantic from Spitzbergen and the White Sea to the Cattegat, as well as on the north-eastern coasts of America"[1] (British Conchology, vol. ii. p. 316).

II. *Leda rostrata.*—Forbes gives this as a synonym of the *Nucula oblonga* of Brown (*op. cit.* p. 419), which Jeffreys again says is the same as the *Leda pernula* of Müller, and tells us he dredged a young live specimen and a small single valve of the shell in 80 fathoms off the Shetland coast; single valves not living have also occurred in Loch Duich, in Ross-shire, and St. Magnus Bay, on the west coast of Shetland (Jeffreys, *op. cit.* vol. ii. p. 158, and vol. v. pp. 173 and 174).

III. *Leda hyperborea.*—Is not referred to in Forbes's detailed list of glacial shells, nor do I know what species is meant by it.

IV. *Tellina Grœnlandiœ.*—Sars deems it a mere variety of *Tellina balthica*, whose wide distribution over the seas of Northern Europe is well known. The variety *Grœnlandica* is now found living in the Gulf of St. Lawrence (Forbes, *op. cit.* p. 411).

V. *Tellina calcaria.*—Jeffreys says this shell is found on the Danish coasts of the Baltic, and northward as far as Spitzbergen, as well as on the shores of Asia and America, from Behring's Straits to Massachusetts (*op. cit.* vol. ii. p. 390). In a later volume he adds that a fine perfect and fresh but dead specimen of it was dredged by the late Dr. Möller off Fan Isle, between the Orkneys and Shetlands, while he himself got a valve in the same condition on the west coast of Scotland (*id.* vol. v. p. 187).

VI. *Mya truncata*, var. *β Uddevallensis.*—This is the more northern variety of the ordinary *Mya truncata*. The normal form has been dredged on the Dogger Bank and in Shetland and the Bay of Biscay. I am not aware that the variety *Uddevallensis* has occurred in our seas, but Jeffreys says he dredged an intermediate form in Dourievoe in Shetland (*op. cit.* vol. iii. p. 70).

VII. *Saxicava sulcata.*—There is much doubt whether this species be now living at all (see Forbes, *op. cit.* p. 410).

VIII. *Pecten Islandicus.*—This shell is found living on the Norwegian coast from Finmark to Bergen, and has been dredged in a semi-fossil state in the Gulf of Naples (Jeffreys, vol. v. p. 166), where assuredly a Glacial Sea properly so called is most improbable.

IX. *Terebratula psittacea.*—This is the *Rhynchonella psittacea* of other writers. It occurs living in Finmark as far south as Tromsö, but valves of it have been on several occasions dredged in the British seas (Jeffreys, vol. ii. p. 23, vol. v. p. 164; Forbes, *op. cit.* p. 406). Forbes gives it as from the seas of Newfoundland, Labrador, Greenland and Norway.

X. *Fusus cinereus.*—This shell has been described from the coasts of the United States (Forbes, *op. cit.* p. 425).

XI. *Fusus scalariformis.*—A synonym for *Trophon clathratus.* Jeffreys tells us it inhabits Spitzbergen, Iceland, Norway and the Faroe Islands, and the coasts of Northern Asia southwards to Japan, as well as Greenland and the Eastern and Western coasts of North America (Jeffreys, *op. cit.* vol. iv. p. 321).

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[1] Risso has recorded it, under the name of *Cyprina Montagui*, as fossil in the "terrains diluviens" at Nice.

XII. *Fusus Fabricii.*—Jeffreys only gives Greenland and the White Sea as the habitat of this shell (*op. cit.* vol. iv. p. 322).

XIII. *Littorina expansa.*—This is apparently the *Turbo expansus* of other writers, and the only habitat I can find for it is that given by Forbes as Arctic Seas, and coasts of America.

XIV. *Margarita inflata.*—The *Turbo inflatus and Turbo Grœnlandicus* of other writers. It lives, says Jeffreys, in every part of the Arctic Ocean, and on the coasts of the White Sea, Scandinavia, Iceland, Canada, and the States of Maine and Massachusetts, and he mentions also its occurrence as local, but not uncommon, about the West of Scotland, the Orkneys and Shetlands, in Dunnet Bay, Caithness, etc. (*op. cit.* vol. iii. p. 299).

XV. *Velutina undata.*—This shell occurs in the seas of Boreal America (Forbes, p. 422).

XVI. *Natica clausa.*—This shell occurs in Scandinavia as far south as the Christianiafiord[1] (Jeffreys, vol. iv. p. 229).

This examination is assuredly very impressive. Of the various shells enumerated by Forbes and others as proving glacial conditions to have surrounded them when alive, there is hardly one which is not still living in the North Atlantic at the present moment under conditions completely different to those we describe as glacial. No doubt these shells do live and thrive in very high latitudes, and doubtless also have their focus there at this moment; but it is no less true that they extend down into the temperate regions of our own seas and those of the United States and of Southern Scandinavia. If the whole of the mollusca of the beds we are dealing with belonged to the same facies, we should be bound no doubt to conclude that the conditions of South Greenland or of Iceland prevailed here when these shells were living; but the fact is this class forms a small proportion of the whole. Here we must at once say that Forbes's method of tabulating the results of his examination of all the beds together will no longer be deemed satisfactory. We have now the clearest evidence both in Scandinavia and in Britain that some of the beds have a much more arctic facies than others. We have in both areas beds which apparently represent the old sea-bottom of mud or sand with the shells still remaining *in situ*, bivalves standing erect with both valves intact, and with all the appearance of being undisturbed. These are the lower beds. For the most part, so far as I know, they occur at low levels and are characterized largely by shells of an arctic type.

(*To be continued.*)

## VII.—THE PERMIAN AND TRIAS—REJOINDER TO PROF. HULL.

By Rev. A. IRVING, B.A., B.Sc., F.G.S.;
of Wellington College.

PROFESSOR HULL'S criticisms (pp. 491–5 of this volume) on a former paper of mine on the "Classification of the Permian and Trias" lay upon me the burden of a brief reply. I may say that Prof. Hull seems to suppose that the task which I had set myself was more ambitious in its scope and aim than I was conscious of; it was *not* my purpose "to review the whole question of the relations of British Permian and Trias" in a paper which was limited by its title to the European rocks, and from which these systems in other parts of the world were intentionally omitted. My idea was rather to give to readers of the GEOL. MAG. an opportunity of forming some judgment on the results which might be fairly gathered from a digest of the opinions collected from the various members of the "Sub-Committee on Permian and Trias," taken along with the information which exists in the literature of this subject in England and on the Continent, more especially in Germany; and to raise discussion thereupon before the assembly of the Berlin Congress in 1884. My starting-point in this investigation was the elaborate table of the Permian and Triassic rocks of England and the Continent, which Professor Hull himself was good enough to send in to the Committee, before the duty was entrusted to me, in conjunction with Mr. De Rance, of doing the work of 'Reporters' of the Sub-Committee. I had read and seen enough of Continental geology to perceive at once how inadequately Professor Hull had represented that side of the question in his table; and it was with much surprise that I found so high an authority giving a reference (and his only reference) for information on the Muschelkalk Formation to a statement contained in about half a dozen lines of De la Beche's Manual of Geology, more than fifty years old. It was somewhat incomprehensible to me that he should go back so far for information, and thereby ignore the labours of a whole generation of such workers as the two Credners, Quenstedt, von Hauer, Gümbel, Zittel, Geinitz, and a host of others, 'men of renown' wherever these formations are intelligently studied. Here I may be permitted to thank Prof. Hull for the great services which his otherwise copious list of references has rendered to me; I assure him that I have worked them out carefully and honestly, and that had he been good enough to add to them a reference to the "Survey Memoirs of South Lancashire Coalfield, etc.," these too would have been carefully studied. As it is, I must confess that I have overlooked them, though it still remains possible for me to consult them. This point therefore I must beg to waive for the present.

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[1] Dr. Van Geuns discovered it in a Pliocene bed near Palermo.

Had I started in the investigation committed to any very definitely expressed opinions, it might have been suspected by some, who shirked the trouble of following me in wading through the mass of literature which I have had to consult, that I was not quite proof against the temptation to twist things to answer my own ends. But apart from the folly of such a course, when the literature of the subject is open to the whole world of critics, it may suffice, in order to allay even Prof. Hull's suspicions, to mention that at the outset I was certainly far more inclined (in common with several geologists of no mean standing) to think much less of the distinction between Permian and Trias than the investigation of the subject has led me to do, as any impartial and unprejudiced reader of my paper can see for himself. I can assure Prof. Hull that I did not begin with any dire design of smashing to pieces the beautiful tripod image of a "Palæozoic Trias," which the great Murchison set up for the veneration of geologists, and for which the learned Professor seems to have a lingering affection; the conviction, not only of its meaninglessness, but of its mischievous fertility in confusion of ideas, grew upon me gradually as I went on with the subject. As it is, one cannot fail to read with some satisfaction Prof. Hull's own admission that he is "almost inclined to concur that there is but little evidence to support the view of a threefold division of the Permian beds" (p. 493). So much for the general drift of my paper.

I now come to matters more of detail which Professor Hull has touched upon. In the first place he says that I "quote his name as a supporter of the view that it (*i.e.* the Sandstone of the Vale of Eden) is of Permian age." My reply is that *I have not quoted Prof. Hull's name in this way;* nor do I fear to challenge him to show a single passage in my paper in which I have connected his name directly with the "Sandstone of the Vale of Eden." The only three occasions in which his name is mentioned in any such connexion are in the two paragraphs, in the earlier part of the paper, the one beginning, "It is no wonder that such special pleading . . . ," the other, "In *Siluria* there is much vague talk . . . ." In these three cases I have been studiously guarded in the use of language, out of consideration both for Prof. Hull's susceptibilities and for my own wish to put things in the truest possible light. What I do say is (*a*) that "It (*i.e.* the triple classification of the Permian System as put forth by Murchison) was adopted by Prof. Hull in a paper read by him before the Geological Society of London," and I give the reference to this paper, Q.J.G.S. vol. xiv. This statement any one can verify therefore for himself by a simple act of reference. (*b*) Nearly a page further on I say, "The classification put forward by Murchison still finds favour in some quarters; and quite recently so high an authority as Prof. Hull has proposed it for the acceptance of the British Committee." Prof. Hull has surely been caught here "reading the spirit of the commentator into the text." The readers of the GEOL. MAG. are doubtless capable of giving to language its natural construction, and will hold me responsible only for my *ipsissima verba*, not for another person's version of my statements. On this latter point the question therefore narrows itself to the categorical answer to be given to the question: "Did Prof. Hull, or did he not, propose the threefold classification (after Murchison) of the Permian System for the acceptance of the British Committee?"[1]

Prof. Hull states "that the evidence (as to the particular horizon of the Sandstones of the Vale of Eden upon which Murchison rested his claim) was rather of an inferential and indirect nature;" and so far he admits substantially the force of the reasoning adopted by Mr. Goodchild, to which I have referred in that part of my paper in which Prof. Hull's name occurs. He then goes on to say that he is quite prepared to "fall back upon Prof. Sedgwick's views as soon as the officers of the Geological Survey shall have definitely pronounced in their favour;" yet in the sequel he does not hesitate to reject the testimony of two several officers (not certainly speaking *ex cathedrâ*) of that much respected body in favour of such views: the evidence of two others (some of which is most to the point) he ignores altogether.

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[1] On referring to the original document I find that the "Upper Sandstone of St. Bee's Head" is mentioned expressly by Professor Hull as a part of the "Upper Permian."

As regards the joint paper of Murchison and Harkness on the Edenside rocks, what Prof. Hull urges goes certainly to show Harkness's modesty in surrendering so soon the views he had previously expressed. Those who know anything of the contests which Murchison waged with Sedgwick on the one hand, and with M. Jules Marcou on the other, will reserve to themselves the right of forming a judgment on this matter.

Two points raised by Prof. Hull remain to be specially dealt with:

1. Mr. Strahan's view, which has been summarized in the Report of the Proceedings of Section C. of the British Association, 1881. Will Professor Hull be good enough to show by reference to this how I have misrepresented Mr. Strahan? If he cannot show this, the quarrel remains with Mr. Strahan, who, I dare say, can take care of himself. I may add though, that I was present at the meeting of the Section, when the said paper was read, and with the sections before the meeting had a better opportunity of judging of the paper than the mere summary of it affords. It is a pity that Prof. Hull, who was then in York, should not have refuted Mr. Strahan's arguments at the time. The palæontological evidence cited by Prof. Hull certainly shows the presence of the Magnesian Limestone series in South Lancashire, which no one ever called in question: I fail utterly to see how Prof. Hull can regard the strata which furnish such evidence as the "equivalents of those referred to by Mr. Strahan," without at the same time surrendering the question of these latter being "Upper Permian."

2. In a footnote Prof. Hull shows himself very incredulous of evidence which he does not like. I presume that he is prepared to allow considerable weight to any views which Mr. De Rance may express on the Permian strata of the Lancashire area; and in this note he is indirectly bearing his testimony to the value of opinions from such a quarter. Whether or not Prof. Hull's incredulity may be overcome, I know not; though he could easily have obtained from his colleague an affirmation or a denial of what had been attributed to him by me, if he had cared very much to know what Mr. De Rance's views really were. At any rate the readers of the Geol. Mag. will be able to judge for themselves, by comparing the following literal transcript from a MS. in Mr. De Rance's own handwriting with the statement made in my paper:

PERMIANS OF LANCASHIRE.

| | |
|---|---|
| *North Lancashire.* | Furness Abbey and Hawcoat. |
| Upper Permians. | (St. Bee's Sandstones). |
| Middle Permian. | Magnesian Limestone of Stank (Schizodus). |
| Lower Permian. | (Penrith Sandstone, absent.) |
| *Lancashire Fylde.* | |
| Upper Permian? | (Garstang Sandstones.) |
| *South-West Lancashire.* | |
| Upper Permian. | (Absent.) |
| Middle ,, | Magnesian Limestone, 6 feet at Skillaw Clough. |
| Lower ,, | Marls, 30 feet.<br>Sandstone, 40 feet. |
| *South Lancashire.* | |
| Middle Permian. | Marls and Limestones (Schizodus) 300 feet. |
| Lower ,, | Collyhurst Sandstones 300 feet at Manchester thickening north-east to 1000 feet. |
| ............ | Unconformity. |

It is obvious that I could not give a reference to an unpublished paper; but my own statement was: "He (Mr. De R.) considers the 'Upper Permian' of the Survey to be wanting in South Lancashire, and is doubtful if the Garstang Sandstones ought to be so considered. Mr. De Rance also considers the so-called 'Upper Permian' of North Lancashire to occupy the same horizon as the St. Bee's Sandstone." Further comment is needless.

## VIII.—ON THE DISCOVERY OF CAMBRIAN ROCKS IN THE NEIGHBOURHOOD OF BIRMINGHAM.[1]

By CHAS. LAPWORTH, F.G.S., ETC.,

Professor of Geology and Mineralogy, Mason Science College.

THE geology of the neighbourhood of Birmingham is one of more than ordinary interest, owing to the great variety of geological formations exposed within its area. Its rocky structure was investigated about thirty years since by the officers of the Geological Survey of Great Britain, and its several geological formations laid down upon their maps, and described in detail in their various explanatory memoirs. Some of these publications—notably the maps and descriptions of the South Staffordshire Coalfield—have subsequently become classic in the literature of Geology. Since these publications were issued, however, the science of Geology has made great advances, more accurate and detailed methods of research among the older rocks have been developed, and their application to the study of the strata of the Birmingham district has recently resulted in the detection of several most interesting facts which escaped the notice of the earlier investigators.

In the geological history of the Birmingham district three grand historical periods have long been recognized—the deep-water period of the Silurian, the Estuarine period of the Carboniferous, and the Continental or inland-lake period of the Permian and Triassic.

The oldest strata of the region have hitherto been supposed to be of Upper Silurian age. They compose the rocks of the Lower

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[1] Reprinted from the Proceedings of the Birmingham Philosophical Society, vol. iii. page 234.

Lickey ridge, which extends from the railway station at Barnt Green to the new Asylum near Rubery. These rocks consist of quartzites (or intensely hardened sandstones), and are largely quarried for road-metal, for which their intractable character pre-eminently fits them. They were supposed by Sir Roderick I. Murchison and others to be of the age of the Llandovery formation, which forms the base of his Upper Silurian system (as unquestionable Llandovery fossils have been procured in abundance from what appeared to be the highest beds of the quartzites at Rubery and elsewhere), and to owe their present indurated character to "metamorphic action."

The author, who first studied these Lickey quartzites in company with Mr. S. Allport, F.G.S., in October, 1881, felt certain, upon general grounds, that they were of pre-Llandovery date; and, during the discussion which followed the reading of Mr. W. J. Harrison's paper upon the "Fossiliferous Quartzites of the Drift," read at the meeting of the Birmingham Philosophical Soc., Feb. 9, 1882, expressed his conviction that these Lickey quartzites would eventually be demonstrated to be of pre-Silurian age—that the local Llandovery beds would be found to overlie them unconformably, and to owe their superficial resemblance merely to the fact that they were actually composed of the reconstructed debris of the quartzite itself. This view was supported by Mr. T. S. Houghton, F.G.S., who had visited the Rubery section some years previously, and felt assured that the visible phenomena could best be explained upon this suggested hypothesis of an unconformity.

Early in March last the calculated unconformity between the quartzite and the Llandovery was detected by the author in company with his friend Professor Hill, M.A., of Mason College, and abundant evidence obtained to place it beyond question that the quartzites lie unconformably beneath the Silurian rocks, which latter are made up of the reconstructed fragments of the quartzites, and rest upon their eroded edges. A short account of these phenomena was given to the public in the Introductory Lecture of the author's summer course of Local Geology delivered at Mason College on April 25th. The same facts appear, however, to have been detected at an earlier date by Mr. T. S. Houghton, who communicated a short note upon the subject to the meeting of this Society ("Note on the Age of the Quartzite of the Lickey," read May 11th, 1882), and who has thus the credit of being the first to break ground in this new departure in the history of the geology of the Birmingham district.

Quartzites resembling those of the Lickey occur in great force between Nuneaton and Atherstone, on the eastern flank of the North Warwickshire Coalfield, where they have been mapped by the Geological Survey as Millstone-grit, and it was believed by the author that these also would prove to be of pre-Silurian age. On communicating his views to his friend, Mr. W. J. Harrison, F.G.S., the author found that he also had arrived at the same conclusion, and early in May, Mr. Harrison and the author visited the Nuneaton quartzites in company, and recognized the general identity of the beds with the Lickey quartzites, and their superiority to a series of slaty and igneous rocks which rise out below the Trias of the neighbourhood of Caldecote. In addition, they also reached the conclusion that the so-called Lower Carboniferous shales of Stockingford, which overlie the quartzite, would be found to be also pre-Silurian in age. The truth of this conclusion was demonstrated by the author the day following, by the discovery of Cambrian *Lingulidæ*, and subsequently by the detection of many of the most typical Upper Cambrian Brachiopoda and Trilobites within them,—identical with or representative of the well-known species:—

*Acrotreta socialis*, Linnrs.
*Obolella Salteri*, Dav.
*Lingulella ferruginea*, Hicks.
*Kutorgina cingulata*, Billings.
*Agnostus pisiformis*, Linn. *Var.*
*Lingulella Nicholsoni*, Callaway.

Within the same week Mr. Harrison detected similar Cambrian shales upon the opposite side of the East Warwickshire Coalfield, in the neighbourhood of Dost Hill, and elsewhere.

The finest exhibition of these Cambrian rocks is that afforded by the Nuneaton sections. Here our investigations show that a range of country, ten or twelve miles in length by two miles in width, is occupied by rocks of Upper Cambrian age. They fall into two main divisions—a lower division of thick-bedded quartzite (Hartshill quartzite), possibly 1,000 feet in thickness, and an upper division of red, grey, and black shales, with abundant intrusions of hornblendic trap, and having an apparent thickness of nearly 2,000 feet.

The lowest zone of the quartzite is a coarse breccia, made up of fragments of red and green felspathic rocks, slaty shales, and various quartz porphyries. These have apparently been derived from an older series of igneous and altered strata, a few beds of which may be seen rising out from below the basal quartzites in the slopes near Caldecote House, Nuneaton.

The upper beds of the quartzite pass up by gradual intercalations of argillaceous matter into the basement zone of the *Stockingford Shales*. This zone consists of purple mudstones crowded with examples of small Brachiopoda of the genera *Lingulella* and *Obolella*. The higher divisions of the Stockingford shales are grey and black mudstones, filled with igneous intrusions, and faulted down in a long-curved strike fault against the coal-bearing beds of the Upper Carboniferous.

The presumed basement-beds of the Lickey quartzite, as laid open along the road between Rubery and Barnt Green, show included fragments of igneous and fragmentary rock, identical with those of the basement beds of the quartzite of Hartshill. A series of altered purple and green felspathic rocks—breccias, and sandy shales—from which these may possibly have been derived, has been detected by the author, apparently rising out from below the Lickey quartzites, at the southern end of the Lickey ridge, in the stream near Barnt Green railway station. Similar rocks have subsequently been detected at several neighbouring spots by other geologists—by Messrs. T. S. Houghton, F. Martin, and Walcot Gibson.

How these old pre-Cambrian and Cambrian ridges of altered and

**unaltered rocks, which we have thus recently discovered, stand related to the remarkable breccias and boulder beds of the Permian and Trias of the Birmingham neighbourhood, is not yet fully worked out. That they are overlain upon their flanks by representatives of all the subformations of the Silurian, as developed upon the Malverns, has recently been determined by the author and his students. That from these local ridges (many of which are now buried from sight by more recent accumulations), and not from distant Welsh rocks, the supposed Permian glacial boulders might originally have been derived, may now be suspected, and one of the most vital difficulties in the interpretation of the rocky structure of the district will thus disappear from sight. That they afforded the majority of the innumerable quartzite pebbles found in the boulder-beds of the Trias of the Midlands is even more probable, and thus another and even more important fact becomes naturally accounted for.**

## NOTICES OF MEMOIRS.

### ON THE STRUCTURE OF THE HEAD OF ARCHÆOPTERYX. By W. DAMES.[1]

THE *Archæopteryx* in the possession of the Royal Mineralogical Museum of this kingdom [Prussia] will be made the subject of a detailed description accompanied by figures. By uncovering some bones hitherto imbedded in matrix, a better knowledge has been gained of the structure of the head. When the specimen was acquired for this collection, the skull showed on its exposed right side two large apertures. The posterior hole, situate under the roof of the skull, was easily identified as the orbit of the eye; a view the more evident since the cavity contains a well-preserved sclerotic ring, which is formed of a single row of overlapping scale-like, bony plates, as in so many living birds. The anterior edge of this eye-cavity is formed by a small bone, which, turning somewhat backwards, reaches to the base of the skull. This bone is now regarded as the lachrymal. It forms the hinder boundary of a second aperture which is large and of rounded triangular form. In the middle of this cavity lies a crushed fragment of bone which has no natural connexion with the adjacent parts of the skull. This aperture has been determined as the nasal cavity by Vogt and Marsh, in their accounts of the head of *Archæopteryx*. The specimen, however, shows that the anterior part of the skull then laid imbedded in the rock, and the contour of the head has only been shown by carefully clearing away the matrix. This development yields the remarkable result that in front of the opening hitherto considered nasal, lies a third opening which is 9mm. long, of sharp elliptical form and placed oblique to the long axis of the skull. It is separated posteriorly from the middle opening by a small bony bridge. It is bounded above and in front by a very thin bone, which is a part of the premaxillary, which does not reach the extremity of the skull. In front of it lies another portion which is about 4mm. longer which is triangular, equal-sided, and forms the end of the beak.

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[1] Communicated by Herr Ewald, 27 July, 1882, to the Berlin Academy. Translated by Professor H. G. Seeley from a separate copy, extracted from the *Sitzungsberichte*, vol. xxxviii. p. 817. 1882.

This opening, which is entirely surrounded by the premaxillary, is affirmed to be the nasal aperture. By its discovery the resemblance of the skull to that of living birds is shown to be much greater than was formerly believed. As in the bird, three apertures lie on the side of the skull. The hinder one is the orbit; the middle one is surrounded by the lachrymal behind and the premaxillary and maxillary in front and below; while more forward is the nasal aperture, entirely in the premaxillary bone. Having established this analogy with living birds, the study of other parts of the skull becomes much clearer. Thus the crushed portion of bone in the middle aperture is seen to be the inner ascending process of the maxillary bone. And a longer bone running back to the base of the skull and forward, beneath the orbit, is a part of the vomer. Further, the quadrate bone, though not clearly determined by its characteristic form, is recognized by its position. And immediately in front of it is a small bone only just projecting from the matrix which from its position can only be the pterygoid.

There is little preserved of the roof of the skull, only broken fragments of the frontals, and the brain cavity filled up with calcareous spar. The back of the head is wanting. A further result from clearing away the matrix is the exposure of the dentition. Two small teeth standing under the middle opening were already visible in the natural exposure. Besides these there are now ten teeth in all to be seen in the jaw. The most forward is about 2 mm. from the end of the beak; yet there are traces that one or two teeth stood in advance of this, so that the dentition reached to the extremity of the beak. The teeth are about one mm. long, conical, very sharp, and as far as a single small place with well-preserved upper surface lets one see it, shining, smooth, and without perpendicular furrows or ridges. The interspace between the separate teeth is scarcely 1 mm. long. Marsh considered that the teeth were limited to the premaxillary bone, since the last occurred under the nasal opening. But according to the interpretation now brought forward, the aperture formerly termed nasal is the middle hole of the three on the side of the skull, and it is considered that the dentition is not limited to the premaxillary, but also extends to the maxillary bone, or at least to its anterior part. Marsh further put forward the conjecture that the teeth were placed in a groove, but the present examination gives no support to that view, and it rather appears that every tooth stood in its own alveolus. The lower jaw is still in its natural position, *i.e.* in its union with the quadrate bone with the upper margin lying close to the skull which incloses it. It shows a postarticular process, curved behind as in the existing genus *Anser*. The position of the lower jaw as well as the closed beak prevents one from seeing whether the lower jaw contained teeth, but I think, with Marsh, this was probable. Under the lower jaw lies a portion of a needle-shaped hyoid bone comparable to that of living birds in its entirely similar form. Those many very weighty resemblances which the *Archæopteryx* shows to the form of skull in the *Pterosauria* will come under discussion in the detailed description. In conclusion, it may be mentioned that the excavation of the shoulder girdle, which is not yet finished, on further investigation may prove that the portion which Vogt considered to be the coracoid is really matrix, so that so far as can be judged from its preservation, the form of the shoulder girdle must be removed from things known. And it has yet to be proved whether the form of this part of the skeleton will support the relation of the *Archæopteryx* to birds or reptiles.

## REVIEWS.

### I.—GUIDE TO THE EXHIBITION GALLERIES OF THE DEPARTMENT OF GEOLOGY AND PALÆONTOLOGY, BRITISH MUSEUM (NATURAL HISTORY), CROMWELL ROAD, SOUTH KENSINGTON. 8vo. 56 pages. With a Plan, and 31 Woodcuts. Printed by Order of the Trustees. (London, October, 1882. Price threepence.)

THE Galleries containing the Mammalian and Reptilian remains having been completely arranged, and most of those set aside for the fossil Fishes, Molluscs, Crustaceans, etc., having received their palæontological treasures, though not yet in every case fully developed, the Trustees of the British Museum have without delay published their first *illustrated* Guide for the use of both scientist and amateur, as well as for the general public, desirous of knowing what these things are,—how they bear on the notions and thoughts of to-day,—and how far Nature to-day resembles herself in the Past.

Much valuable and precise information is given in a condensed form in this "Guide," especially about the higher Vertebrates, with numerous good woodcuts. Several of these are original, and others have been borrowed from first-class books. The classification of the animals, vertebrate and invertebrate, and their distribution in time and space, are points well kept in view; and, except that the special notice of the Corals, Sponges, and some other low or simple animals, which have not yet been arranged in their cases, is postponed for the present, both student and general observer will find this "Guide" a useful little manual for practical, and to a great degree for philosophical zoology recent and fossil (palæontology). J.

### II.—THE GEOLOGICAL CHART. By JOHN MORRIS, M.A., F.G.S., Emeritus Professor of Geology and Mineralogy in University College, London. New and Enlarged Edition. Large Sheet. (Reynolds and Son, Strand, London.)

THE Chart, originating many years ago, has been revised and improved from time to time, keeping up with the progress of geological knowledge, and thus enabling the Student and the Amateur to catch at a glance the main points and chief features of *his subject*. In the present edition the proposed recognition of the

*Oligocene* formation in the Isle of Wight, and the probability of the Bovey beds being of *Eocene* age, are not lost sight of. There is, however, some obscurity about the brackketted equivalent for the *Woolwich and Reading beds.* The localities for the equivalent of the Maestricht Chalk, or "Danian" formation, are not clearly printed. The *Neocomian* including the *Wealden* formation is carefully indicated; but the "Horsham Stone" is set with the "Hastings Sands," instead of with the "Weald Clay," as determined by the "Survey." The older groups of formations are all carefully noted in their order, and as clearly as possible for the student in his preliminary studies. For the "Lower Oolite" and the "Carboniferous," collateral groupings are given for special regions. The Archæan strata are not neglected, Dr. Hicks's "Pebidian" and "Dimetian" being placed in due order, and his "Arvonian" noticed in a side entry. We wish that *Palæopyge Ramsayi* had not been left out of the Longmynd fossils, for it is good and historical; whilst the Oldhamian markings, that are noticed, are doubtfully organic; and a better amphibian than the questioned *Parabatrachus* might have been entered for the "Carboniferous."

But such weaknesses are few, after a careful examination, and probably all that there are, for the author of the Table is a consummate master of his science, and knows fossils as only a complete palæontologist can know them. His knowledge also of the range of the fossiliferous and other strata throughout the land is not only extensive, but minute as to details, as shown in some of the columns of this Table, which gives as much information in a condensed form, as to the range and economic value of strata and other rocks, as many a book, pretentious in character, can yield.

The constituents of the metamorphic and igneous rocks are noticed in general terms, useful to the student; but we fear many will be somewhat puzzled by the description given of "granite" and "syenite" after some German lithologists, rather than according to the old-fashioned plan of English works. The igneous origin of the serpentine of the Lizard is not insisted on, as we should have expected it to have been. These are but few, and easily explained, points of weakness; and we have only further to remark as critics that a little more care in the printer's work as to punctuation, etc. (there are very few actual misprints), would have made some passages rather clearer.

The columns (or rather two halves of a long column) on the sides of the Table exhibit the proportionate thickness of the several groups of formations, by the relative space given for each, with its depth in figures; and this is made the more clear and conspicuous by appropriate tints for several lengths, corresponding with the colours given to the formations themselves in the body of the Table.

Showing the regular formations in their succession, their principal fossils, mineral characters, uses in the Arts, their British localities, and relative thicknesses, this Table is admirably adapted for its purpose, namely, of fixing attention upon some of the most important points in geological study quickly and with the certainty of correctness. As such, we have great pleasure and satisfaction in recommending it to the public. J.

III. — UEBERSICHT ÜBER VIERUNDZWANZIG MITTELEUROPÄISCHE QUARTÄR-FAUNEN ZUSAMMENGESTELLT UND MIT BEMERKUNGEN VERSEHEN von Dr. ALFRED NEHRING, Professor a. d. Königl. landwirthsch. Hochschule in Belin. (Abdruck a. d. Zeitschrift d. Deutschen geolog. Gesellschaft, Jahrg. 1880.) [REVIEW OF THE QUATERNARY FAUNA FROM 24 LOCALITIES IN MIDDLE EUROPE, WITH REMARKS THEREON, by Dr. ALFRED NEHRING. (Extracted from the Journal of the German Geological Society, 1880.) 8vo. pp. 41.]

THE author's aim in this paper is to present in a condensed form the results of researches made by himself and other investigators into the Quaternary fauna of Germany and the adjoining countries of Central Europe. Many of the observations have been already published in the proceedings of various scientific societies, but, as it often happens that these are not readily obtainable by the student, a resumé, showing the present knowledge of this subject, is extremely useful.

The paper contains a list of the Mammalia, Birds, Reptiles, Amphibians, Fishes, and Shells, which have been discovered in caves, rock-fissures, and diluvial clay and Loess, in the following localities:—(1) Thiede, near Wolfenbüttel; (2) Westregeln, near Magdeburg; (3) Seveckenberg, near Quedlinberg; (4) Sudmerberg, near Goslar; (5) The Lindenthaler Hyæna-cave, near Gera; (6) The Dwarf's Hole, near Pottenstein in Franconia; (7) Hoesch's Cave; and (8) The Elizabeth Cave in Arlsbachthal, Upper Franconia; (9) A Bone Cave, near Ojcow in Russian Poland; (10) A Cave on the Novi Mountain, 6000 feet above the sea-level, in Tatra, Hungary; (11) Nussdorf, near Vienna; (12) Zuzlawitz, near Winterberg; (13) The Robbers' Cave, between Nurnberg and Regensburg; (14) The Ofnet in Ries; (15) The Hollow Rock in Achthal, near Ulm; (16) Fissures in the Molasse at Baltringen, near Biberach; (17) The Thayinger Cave, near Schaffhausen; (18) Langebrunn on the Danube, near Sigmaringen; (19) The Loess of Wurzburg; (20) The Fox-holes at the Rothen Berge, near Saalfeld; (21) Steeten on the Lahn; (22) The Unkelstein at Remagen on the Rhine; (23) The Caves of Balve in Westphalia; and lastly (24) The Cave of Sureau, near Dinant on the Meuse. In addition to the list of species from each of these places, short descriptions are appended of the positions in which the fossils occur, and reference made to the various authors who have discovered and determined them, and to the public and private collections in which they are now preserved. In a tabulated list of the most important of the fossil Vertebrata, there are enumerated 71 species of Mammals, 7 species of Birds and 4 species of Batrachians and Fishes. A glance at this list shows that the fossils met with in these Central European caves correspond to a very large extent with those present in similar positions in this country. The most abundant and widely distributed forms are the Cave-Lion, Hyæna, Wolf, Fox, Arctic Fox, Cave-Bear, Weasel, Water-Rat, Lemming, Hare, Reindeer, Ox, Horse, *Rhinoceros tichorhinus*, and *Elephas primigenius*. The smaller Insectivora, Carnivora, and Rodents, are also well represented. G. J. H.

# REPORTS AND PROCEEDINGS.

## GEOLOGICAL SOCIETY OF LONDON.

November 1, 1882.—J. W. Hulke, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "The Hornblendic and other Schists of the Lizard District, with some Additional Notes on the Serpentine." By Prof. T. G. Bonney, M.A., F.R.S., Sec.G.S.

The author described the metamorphic series, chiefly characterized by hornblendic schist, which occupies the southern portion of the Lizard and an extensive tract to the north of the serpentine region, besides some more limited areas. He found that this series was separable into a lower or micaceous group—schists with various green minerals (often a variety of hornblende), or with brownish mica; a middle or hornblendic group, characterized by black hornblende; and an upper or granulitic group, characterized by bands of quartz-felspar rock, often resembling in appearance a vein-granite. These are all highly metamorphosed; yet the second and third occasionally retain to a remarkable extent indications of the minuter bedding structures, such as alternating lamination and current bedding of various kinds. They form, in the author's opinion, one continuous series, of which the uppermost is the thinnest. The general strike of the series, though there are many variations, is either N.W. or W.N.W.

The junctions of the Palæozoic with the metamorphic series at Polurrian and at Porthalla were described. These are undoubtedly faulted; and the two rocks differ greatly, the former being a slate like any ordinary Palæozoic rock, the other a highly metamorphosed schist. Moreover, fragments of the hornblende schist and a kind of gneiss occur in a conglomerate in the former, S. of Nare Point.

The author considers the metamorphic series (the microscopic structure of which was fully described) undoubtedly Archæan, and probably rather early in that division. The rocks of the micaceous group have considerable resemblance to the greenish and lead-coloured schists of Holyhead Island and the adjoining mainland of Anglesey, and of the Menai Strait.

Two outlying areas of serpentine, omitted in his former paper, were described—one at Polkerris, the other at Porthalla. The latter shows excellent junctions, and is clearly intrusive in the schist. The author stated that he had re-examined a large part of the district described in his former paper, and had obtained additional evidence of the intrusion of the serpentine into the sedimentary rock with which it is associated. This evidence is of so strong a nature that he could not conceive the possibility of any one who would carefully examine the district for himself entertaining a doubt upon the matter.

2. "Notes on some Upper Jurassic Astrorhizidæ and Lituolidæ." By Dr. Rudolf Häusler, F.G.S.

The Arenaceous Foraminifera obtained by the author are chiefly from the zones of *Ammonites transversarius* and *A. bimammatus* in the Upper Jura of the Aargau; and from the whole Swiss Jurassic formation he has determined about sixty species, including the Textularidæ. They belong to the genera:—

*Psammosphæra.*
*Astrorhiza.*
*Rhabdammina.*
*Marsipella.*
*Hyperammina.*
*Lituola.*
*Reophax.*
*Haplophragmium.*
*Haplostiche.*
*Placopsilina.*
*Trochammina.*
*Hormosina.*
*Webbina.*
*Thurammina.*
*Textularia* (*Plecanium*).
*Bigenerina.*
*Valvulina.*

A few species are identical with Carboniferous or Permian forms; but most of them most nearly approach recent deep-sea species and varieties, although similar forms do not occur in the younger formations. The species described in the present paper are from the zone of *Amm. transversarius*, and are as follows:—*Psammosphæra fusca*, Schultze, *Hyperammina vagans*, Brady, *Reophax multilocularis*, sp.n., *R. helvetica*, Häusl., *R. scorpiurus*, Montf., *Placopsilina arenacea*, d'Orb., *Thurammina papillata*, Brady, and *T. hemisphærica*, sp.n. Most of the recent genera of Astrorhizidæ and Lituolidæ would seem to have been represented by species identical with, or nearly allied to, those now existing, at the time of deposition of the beds with *Ammonites transversarius.*

## CORRESPONDENCE.

### SUBMERGED FORESTS ON THE SUFFOLK COAST.

Sir,—In 1874-5, whilst the river Orwell was being deepened, and a new channel cut, a bed of peat was discovered. This was carefully examined and worked by myself and Mr. Thos. Miller, C.E., the Ipswich Dock Engineer, and the published results appear in the Report of the British Association (Bristol) Meeting, 1875. This peat-bed was as much as nine feet thick, full of the trunks of trees, and from it we obtained several grinders of the Mammoth. It was traced down towards Harwich for a distance of six miles, and, at the time, I pointed out that this ancient forest could only have grown when the land stood relatively so much higher than the present sea-level that the bed of the German Ocean must have been marshy land, probably characterized by similar extensive shallow lakes to those which are so abundant in the flat, eastern parts of Norfolk, where they are known as "Broads."

Fishermen off the Norfolk and Suffolk coasts frequently bring up lumps of peat in their trawl nets, and that the bed of the German Ocean off these parts must be occupied by extensive deposits of this kind is shown by the unfailing supplies. Bones and teeth of Elephant, Ox, Deer, etc., are strewn over the area, and are often dredged up. Those who are acquainted with the magnificent collection of these remains made by Mr. Owles, of Great Yarmouth,[1] nearly all of which were dredged up by Yarmouth fishermen, will be prepared to substantiate the statement that the floor of the German Ocean is occupied by extensive post-glacial deposits, with their characteristic organic remains. A post-glacial forest-bed occurs at Holm Scarf, off the Norfolk Coast, and may plainly be seen at low water. It is a bed of peat in which trunks of trees are imbedded. It was in one of these trunks that Mr. Edwards found a flint implement sticking.

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[1] Now preserved in the British Museum of Natural History.

Within the last few days I have come upon the remains of another submerged forest or peat-bed at Bawdsey, near Felixstowe. It is only visible and accessible at low-water spring-tides, and even then it is seen sloping down into the sea. The cliffs at Bawdsey are formed of London Clay, capped by Red Crag, and they do not waste so rapidly as many other parts of this coast. The London Clay forms the bed of the sea, except near the northern side of the estuary of the Deben. There we find the peat-bed, resting directly on the London Clay. It is about four or five feet thick at its thickest part, but it has evidently been very much denuded, and is now merely a relic of what it once was. Remains of trees are not plentiful in it and the peat contains an abundance of fresh-water and marsh plants, but I found no fresh-water shells. The only animal remains I obtained are the upper part of the skull and horn-cores of *Bos longifrons*, but I was told that bones had frequently been washed out of it. Among the plants a species of *Cyperus* was abundant, and *Sphagnum* was also plentiful. Indeed, the nature of the peat-bed indicates its formation under just such marshy conditions as geologists have assumed the bed of the German Ocean to have been in before the submergence took place which brought the sea-water over it, and so converted England into an island.

The discovery of this remnant of a once extensive peat-bed uncovered only in part even at extreme low-water spring-tides, is therefore interesting as confirming the geological speculations concerning the old marshy plain over which the German Ocean now extends. J. E. Taylor.

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## REPLY TO MR. ALFRED TYLOR.

Sir,—Mr. Alfred Tylor complains that being dissatisfied with certain views of some prominent geologists, I have "ready a theory of my own to meet all the difficulties of the student of Quaternary Geology." My rôle I am afraid is much more humble. It is true that I have spent much time in trying to unravel the difficulties of the surface beds of Western Europe, and have found, as Mr. Tylor no doubt has, that almost every student of them has a different theory. It is true also that, disagreeing with the many and contradictory views that have been propounded, I have tried (I hope in deferential language) to show why they seem incompetent to explain the facts, and having done so have propounded another view; but I neither claim for this conclusion that it explains all possible difficulties, nor that it is necessarily a final view. I do not believe in final views in Science. Every one of us is as a fly on a plate in view of the advancing tide of Knowledge, and we can do no more than frame an hypothesis that shall meet the facts accumulated up to the time when we write. To-morrow a child may find a fresh fact which will not fit our theory. That theory must thereupon go under; but it will have done its work. All I claim to have done is to have framed an hypothesis which will meet *all* the facts known to me. I have not shirked or wilfully evaded any, and I hope I have accumulated a very considerable number as the basis of every step in the argument. Further, the position I am fighting for is only partially mine. I have merely tried to extend to *all* the beds which are confessedly on the same horizon, however different in texture, an explanatory cause which such great authorities as Murchison, Belgrand, and Prestwich, have agreed in assigning to *particular* cases, and to show that the evidence is convergent and cumulative. If I have misstated or misread facts, there is nothing will be more grateful to me than to have my slips pointed out; and if the position is shown to be untenable, it will be surrendered at once, for there is not time in seventy years, which is our portion here, to fight for prestige. Of course when we take a new departure we must adopt the position of Ishmael. We are bound to struggle with those who already monopolize the ground, and I know of few better examples to point the moral than Mr. Tylor himself. He has defended his Pluvial period with ingenuity and skill. He has written about it in a way which has been a delight to myself to read, and although he has not convinced many people that he is right, he has not done the cause of science any the less good service by presenting certain neglected aspects of a difficult problem in a striking light. Mr. Tylor's second and third paragraphs I do not quite understand the appositeness of. In answer to his arguments that the denuding influence of a river upon its channel increases many fold with the increase of its water, I urged that this does not follow, because the motion of a river, especially of a deep full river, is largely limited to the upper and central portions of its current, that it decreases as we get nearer the bottom, while that portion in contact with its channel is nearly quiescent. Do I understand Mr. Tylor to dispute this elementary hydrostatical position, which is not a theoretical one, but has been amply proved experimentally by a succession of observers, and especially by Defontaine and Raucourt? If not, I do not understand the drift of his remarks. I may add by the way that I have found since I published the suggestion that the quiescence of the fundamental layers of water in a river may account for northern rivers so frequently first freezing at the bottom, that the same suggestion had been previously made, unknown to me, by Arago, and I willingly shelter behind his ægis.

Mr. Tylor's claim to have suggested as early as 1853 that the crumpled gravels in the valleys of some of the French rivers were produced by the mouths of these valleys having been gorged with ice, is quite just; but in quoting Mr. Belt I was looking not at this local fact, but at the important theory he formulated which proposed to explain the valley terraces, etc., as lacustrine deposits, the European lake being embanked and pounded back by ice.

DERBY HOUSE, ECCLES, MANCHESTER,
*October*, 1882.

HENRY H. HOWORTH.

## THE PERMIAN AND TRIAS.

Sir,—As my name has been alluded to by the Rev. A. Irving and by Prof. Hull in reference to the classification of these beds in Lancashire, I wish to point out that the former is correct in stating that I do not ascribe the Garstang sandstones, found by me north of Preston in 1869, to "Upper Permian Age," but if he imagines I correlate them with the Trias, he is certainly in error, as I have always considered them the equivalents of the Collyhurst (Lower Permian) Sandstones of Manchester, and so described them in 1877.[1] No one, who has examined the country between Bedford Leigh and Manchester, can for one moment doubt the correctness of the twofold division of the Permian in that area, established by that most able field geologist Mr. Binney, and afterwards established in detail by Prof. Hull. Boring after boring has been made in this district, and the classification has never been shaken; I have since 1868, year by year examined every new section of importance in Lancashire, and since the establishment of the Underground Water Committee of the British Association in 1874, have visited every important boring whilst in progress, and I consider that the evidence afforded by these sections and borings establishes the conclusions of Messrs. Binney and Hull to be founded on fact.

1st. There is good evidence of the Triassic sandstones overlapping the various Permian beds, and occasionally extending beyond them, as between Warrington and Liverpool, as pointed out by me in 1879.

2nd. In the Manchester district there is a distinct twofold division of the Permian, the upper portion consisting of *marls*, with numerous beds of limestones, and the lower part of white, red and variegated sandstones.

3rd. These marls increase in thickness steadily in proceeding eastward from Manchester, being at Worsley 131 feet thick, at Ardwick Station 150, at Openshaw Bore-hole 205, while still further to the north-east they are 245 feet.

4th. The base of these marls are generally conglomeratic, and rest on the Lower Permian Sandstone. This was well seen at the Openshaw boring, which was visited whilst in progress, by Mr. Binney, and by myself; the lower 70 feet of these marls were teeming with fossils, of which I made a collection, now at Jermyn Street.

5th. The Collyhurst Sandstone obeys the same law, of westerly attenuation, being only 10 feet at Albert Bridge, 250 feet at Collyhurst, and no less than 752 at the Openshaw boring, the sandstone in each case resting unconformably on underlying Coal-measures.

6th. In the Openshaw boring, the details of which have been published by Mr. Atherton,[2] the boring was continued in the Coal-measures to a depth of 1300 feet, passing through the well-known Ardwick series of Upper Coal-measure Limestone, so that in this boring no possibility occurs of the Permian Limestones of Upper Permian age being confounded with the Ardwick Limestones.

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[1] Report of Brit. Assoc., Third Report Underground Water Committee.

[2] Trans. Manchester Geol. Soc. vol. xv. 1878.

7th. In the Openshaw boring, the Upper Permian beds are overlaid by 36 feet of true Triassic Bunter beds.

8th. Looking to the westerly attenuation of these Permian beds, there is no matter of surprise in their comparative thickness at Bedford Leigh and Ashton, and their absence at Winwick and Farnworth. C. E. De Rance, F.G.S.,
Assoc. Inst. C.E.

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## THE PERMIAN AND TRIAS.

Sir,—Permit me to reply to Professor Hull's remarks in your last number on my paper on the so-called Permian Rocks near St. Helens (Geol. Mag. Dec. II. Vol. VIII. 1881, p. 433).

In this paper I trace the range of these unfossiliferous rocks, showing that they are similar to the Lower Mottled Sandstone of the neighbourhood, and that they thin out without unconformity with this subdivision of the Bunter in those very directions, in which, had they been Permian unconformably overlapped, they might have been expected to develope. They are thus completely separated from those rocks which are referred to by Professor Hull as containing Permian fossils wherever they occur along the border of the Coal-field, and as being unconformably overlain by the New Red Sandstone. On these grounds I ventured to doubt the correctness of their determination as Permian; Professor Hull merely repeats his belief in its correctness, without offering any explanation of the difficulties which arise in the way of its acceptance.

I also defined an area (including the village of Winwick) in which I considered Permian to be absent. Professor Hull refers to a shaft at Abram, in which these rocks have been proved, as being near Winwick, and as not being described by me. Abram is nearly six miles from the village of Winwick, and about half that distance from the town of Wigan. It is not only outside the area I defined as being devoid of Permian, but is more distant than the Edgegreen section, to which I alluded for the purpose of showing the nearest known occurrence of these rocks.

To defend myself from the charge of presumption in forming an opinion opposed to that of the late Mr. Binney and Professor Hull, I may mention that since Mr. Binney's original examination of this locality and Professor Hull's subsequent survey, when a brewery well and a quarry were the only sources of information, seven shafts at three collieries and three bore-holes have been sunk, all throwing light on the true relations of these rocks, and showing, among other points, that shales equal in thickness to the so-called Permian Marl of St. Helens are not unknown in the Lower Mottled Sandstone of that neighbourhood. My visit was not a flying one, as suggested by Professor Hull; my repeated examinations of the district resulted from instructions, officially received, to make a detailed survey of the whole area in question. A. Strahan.

Market Rasen, *Nov.* 11, 1882.

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